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DISCIPLINE AND LIBERTY WITHIN THE SOCIAL SYSTEM

PROF. F. A. HAYEK has now brought together a series of studies on science and the study of society first published in *Economica* during 1942–44, the essays on L'École Polytechnique which Saint-Simon and Comte and their successors published under the title "The Counter-Revolution of Science" in the same periodical in 1941, and a later study of Comte and Hegel published in *Measure* of June 1951*. The last study, of the extent to which the characteristic approach of our age to sociology is due to the agreement in thought between Hegel and Comte, and the influence of their ideas on social theory, is indeed a natural sequence to those studies of the influence of the École Polytechnique of Saint-Simon and Comte in Britain and Germany as well as in France, which constitute the second part of the book. Both studies attribute the totalitarianism of the twentieth century to the ideas of Hegel and Comte, of Feuerbach and Marx. This examination of the historical role of the abstract ideas described in the first part of the book is lucid and well written; but Prof. Hayek's exposition is scarcely less lucid when he is handling the more abstract or theoretical discussion of the general issues, though some chapters are more readable than others. Indeed, his book has, in fact, a far wider interest than its philosophical approach would suggest, and its close bearing on some of the most important questions of the day should commend it to a much wider circle of readers than professional philosophers or economists.

The central theme of the book is that many of our present difficulties are due to a misinterpretation of the lesson which the conquest of Nature by science and technology has for the ordering of our affairs. Analysing the position which man holds in relation to Nature on one hand, and to the products of his mind on the other, Prof. Hayek urges that the application of some of the concepts and methods of the physical sciences to the interpretation of social problems can lead to serious errors. In essence, his book is a reasoned protest against the mechanical and uncritical application of habits of thought to fields different from those in which they have been formed, and more especially against the application of those methods and ways of thinking developed by the disciplines of the physical and biological sciences to subjects like social studies.

At some points Prof. Hayek's account of the problem and method of the natural sciences may be open to challenge; but his interpretation of the way in which these differ from what is encountered in the social sciences, and of the consequences which follow from attempts to treat the problems of the social services after the fashion of the natural sciences, provide a firm basis for his well-known opposition to social or economic planning in general. Further, this analysis, which suggests the sub-title of the book—"Studies in the Abuse of Reason"—gives a

* The Counter-Revolution of Science: Studies on the Abuse of Reason. By F. A. Hayek. Pp. 255. (Glencoe, Ill.: The Free Press; London: George Allen and Unwin, Ltd., 1952.) 32s. net.

strong hint as to the real cause of difficulties in large-scale organization to-day which are commonly overlooked in discussions on nationalization and other aspects of what is termed the Welfare State. "We flatter ourselves undeservedly," writes Prof. Hayek, "if we represent human civilization as entirely the product of conscious reason or as the product of human design, or when we assume that it is necessarily in our power deliberately to re-create or to maintain what we have built without knowing what we are doing. Many of the greatest things man has achieved are not the result of consciously directed thought and still less the product of a deliberately co-ordinated effort of many individuals, but of a process in which the individual plays a part which he can never fully understand. They are greater than any individual precisely because they result from the combination of knowledge more extensive than a single mind can master."

Prof. Hayek could with some justice have equally sub-titled his book "Studies in the Meaning of Freedom", for in this central passage he comes very near to explaining why, in spite of the demand for 'conscious' control or direction of social processes which is so characteristic of our generation, we can only begin to enjoy freedom when we recognize the limitations of the powers of individual freedom. Failure to do so, and the persistent increase in the demands which are placed on the individuals responsible for directing organizations we create, can only result in breakdown or chaos in the absence of the supermen needed to run them. Ultimately—and not in such a very long run—what is politically possible must be determined less by political desires than by the mental and physical, if not also the moral, capacities of individual men and women.

So far from believing that consciously directed processes are necessarily superior to any spontaneous processes, Hayek agrees rather with A. N. Whitehead that "civilization advances by extending the number of important operations we can perform without thinking about them at all"; and there is a suggestive resemblance between his approach to social planning and organization and the conditions generally accepted as conducive to creative work in any field. Part at least of the importance of this stout championship of individualism lies not so much in its showing that the present tendency to attempt to extend conscious control of society leads straight to totalitarianism as in its support of the moral fabric of civilization. "Any general refusal," comments Hayek, "to accept existing moral rules merely because their expediency has not been rationally demonstrated is to destroy one of the bases of our civilisation." In rejecting planning, Hayek is not advocating chaos or anarchy but urging discipline. His insistence on the need for a rational comprehension of the limitations of human reason leads him to a very similar position to that which Dr. K. E. Barlow reached in a very different way in "The Discipline of Peace" much about the same time Prof. Hayek originally prepared these studies. Not merely the advance but also the very preservation of civilization depend on our obedience to principles which we do not fully understand—the acceptance of existing moral rules and traditions. Hayek's plea that we should be concerned that we do not destroy the foundations of existing structures before we are sure that those of the institutions to succeed them are truly laid is dignified and forceful, and one to be heeded to-day in education and elsewhere.

Scientists themselves are probably now more disposed to recognize the limitations of science and less prone to apply their methods and mental habits in fields where they are not competent than they were when Hayek prepared these essays. But to turn back to Dr. Barlow's plea for discipline is to realize how little progress has been made in the past decade towards achieving an order in which personal liberty and personal discipline fit harmoniously, or towards recognizing that the primary issue is not how we are to treat materials, but how men are to treat each other and the life of the earth which endows them. The real task is still one of education.

On this, too, Barlow and Hayek agree. Barlow remarked, for example, on the need for man to understand as well as to enforce the discipline under which he must live, and on the necessity for such understanding for the existence of initiative and liberty within a social system; while Hayek's insistence on the limitations of reason and of conscious control implies that the determining factor in unconscious control and in securing the efficient use of our resources is the ability and understanding of those individuals of which a society is composed. Hayek, too, suggests that the great misfortune of our generation is that the direction which the amazing progress of the natural sciences has given to its interests is not one which assists us to comprehend the larger process of which as individuals we form merely a part, or to appreciate how constantly we contribute to a common effort without either directing it or submitting to the orders of others. His chapter "Engineers and Planners" is entirely relevant to the current discussions on technological education in Great Britain and on the purpose of university education; and he regards the failure to convey awareness of being part of a social process, and of the manner in which individual efforts interact, as one of the great weaknesses of an education limited to the sciences or to technology. The engineer's job, he points out, is not complete in itself, nor is it easy to assemble all the widely disposed knowledge required. There is a problem of co-operation in which the existence of a gulf between different types of mind may be vitally important.

PLANT DISEASES

Plant Diseases

By Dr. F. T. Brooks. Second edition. Pp. xiii+458. (London, New York and Toronto: Oxford University Press, 1953.) 38*s*. net.

IT is gratifying to see, after the lapse of nearly a quarter-century, that a new edition of the late Prof. F. T. Brooks's book on plant diseases has been produced. While the style and scope of the new

volume (the greater bulk of which discusses a large number of specific diseases) remain much the same as in the first edition of 1928, additional matter has been included without increasing the thickness of the book, by the adoption of smaller print and thinner paper.

The first edition has been completely re-written, and a few more illustrations have been added. An exceedingly valuable and all too brief introductory section on the various aspects of plant disease is succeeded by a short chapter on non-parasitic diseases which, the late author points out, is only an introduction to this big group of plant maladies; a short section, again all too brief, on virus diseases completes all the information of a general nature before the reader comes, in the third chapter, to the accounts of specific diseases, occupying eighteen chapters of the book, which closes with a section on fungicides. An excellent feature, on which much care and labour have been expended, is the list of references at the end of each of the twenty-two chapters, all of which, with the exception of the first three, are devoted primarily to British plant diseases together with others of importance wherever they occur, including also those of tropical crops.

Valuable though the late Prof. Brooks's new edition will prove to all interested in plant diseases, one feels that this distinguished mycologist and teacher would also have served with equal distinction in his capacity as general editor to a more comprehensive volume dealing at greater length only with the general principles of his subject. With the rapid expansion in our knowledge of plant pathology during recent years, despite the production of valuable manuals at the hands of numerous specialists, there is a strong feeling among teachers, students and research workers alike of the need for greater co-ordination of this extensive new material so as to present in a general way the various aspects and factors relative to disease. To this end, one regrets that the collaboration which the late author had sought did not fully materialize; and with the wealth of talent so close to his hand and of those whom he mentions in his preface to the new volume, all of them specialists of wide experience in their diverse spheres, one feels that such a comprehensive collective work on the general principles of plant pathology would not only have proved of inestimable value to both teacher and student, but would also now remain as another edifice to the worthy memory of a master scientist and teacher.

S. G. JONES

CONSEQUENCES OF ATOMIC POWER

Atomic Power

An Economic and Social Analysis; a Study in Industrial Location and Regional Economic Development. By Walter Isard and Vincent Whitney. Pp. xi+235. (London: George Allen and Unwin, Ltd., 1952.) 37*s*. 6*d*. net.

OUR grandparents, while great believers in progress through diligence and thrift, seem to have doubted the possibility of a substantial improvement in the lot of the majority of mankind. This attitude was challenged by the radicals, and between the two World Wars it gradually became old-fashioned not to believe that nationalization and the planned use of all natural resources would introduce an age of peace and plenty. Since the Second World War, however, it has begun to be whispered that natural resources look a bit inadequate compared with even the foreseeable demands of a steadily increasing world population. In this dilemma the latest bolus proffered to us is the promise of cheap and unlimited nuclear power for industry.

The authors of this book (respectively an economist and a sociologist) examine the technical, economic and social problems associated with atomic power and reach a number of very interesting conclusions.

In the first place, the authors think that in the foreseeable future nuclear power is unlikely to be cheaper than, or even as cheap as, power from conventional energy sources. The best available figures suggest that the capital cost of a nuclear power station will be at least double that of the equivalent coal-fired station; since the nuclear plant may have a shorter life, the *annual* capital charges will be up by an even greater factor, and in these circumstances the nuclear plant is not competitive. This situation may, of course, improve.

Second, the authors think that the influence even of low-cost nuclear power on the location of industry, on industrial output and on standards of living will be much smaller than is often supposed. In the manufacturing industries, the ratio of the cost of fuel and purchased energy to both the value of the product and the value added in manufacture is usually quite small, and if power cost nothing the direct effect on output and costs would not be great. The main factors influencing the location of industries are proximity to raw materials and to markets; the availability of water, food, labour and capital; the proximity of other industries, the momentum of an early start and a favourable climate. Only a few industries are definitely power-oriented; atomic power does not remove the many other determinants of industrial location.

Third, the authors think that nuclear power, if and when it comes, is most likely to benefit advanced industrial communities and may place industrially backward nations at a greater disadvantage than they are to-day. For example, when capital costs are high, areas in which interest rates are high are at a disadvantage relative to areas in which interest rates are low.

If there are economies of scale, areas where the power demand is large should be able to obtain power at lower prices than areas where there is only a small unfolding demand. Furthermore, just these latter areas are apt to be short of capital to finance the industrial expansion that would cheapen power.

Considerations such as these obviously place the economically under-developed nations at a general disadvantage so far as access to nuclear power is concerned. This disadvantage is accentuated by their lesser ability to provide the special skills and industrial facilities likely to be required by nuclear power plants.

It is interesting to note that the authors suggest that the U.S.S.R. may have more to gain from atomic power than the United States. "Relative to the U.S.A., Soviet energy resources no matter how stated are inferior, and the areas within the country in which fuel and energy resources are critically short are more numerous. On the other hand Russia's

more rapid growth of population, the associated greater mobility of its labour force, its more rapidly expanding market, and its less mature economy, which is conducive to fuller utilization of major innovations, all point to the probability that Russia will be able to exploit a new energy resource such as atomic power most effectively and extensively. It is not merely that Russia can; it is also that the believed necessity to do so is greater."

The first 23 pages of the book deal with the technical background of atomic power. This section gives a fair survey of the field. There is, however, a lack of emphasis which leaves a reader in some doubt about the relative importance of the various topics touched on.

The second part of the book (108 pages) is devoted to costs and industrial applications. The five chapter headings are: the costs of atomic power; atomic power and location theory; atomic power and the location of specific industries; the iron and steel industry; the aluminium industry. All these matters are discussed in a competent, informative and interesting way.

The third part of the book (76 pages) deals with atomic power in relation to the process of regional economic development, and considers its possible impact upon regional economies in various stages of such development. Particular attention is given to the cultural resistances which impede the introduction of new ideas and techniques, and Brazil is taken as a case study. The fourth part (5 pages) is a summing up.

This book is obviously the outcome of considerable research and reflexion, is well written and attractively printed. It can be recommended without reservations to all persons interested in the future of atomic power.

B. L. Goodlet

FOREST MANAGEMENT

Planned Management of Forests

By N. V. Brasnett. Pp. 238. (London: George Allen and Unwin, Ltd., 1953.) 20*s*. net.

THE nature of forests is such that their management requires long-term planning if their productivity is to be increased progressively or indeed maintained. It is the absence of management in this sense that is the usual reason for the impoverishment and, in many instances, destruction of forest which still continues in many parts of the world. The problems of long-term development of forests to secure maximum and sustained production were first tackled in France and Germany, and in the course of time various management techniques have been developed which are appropriate in various degrees to the conditions in these and other European countries. The current techniques, however, may not be applicable to forests in other parts of the world that are only now coming under management for the first time, although some crude method used earlier in Europe may be appropriate. Students trained in the university forestry departments in Britain go to all parts of the British Commonwealth, and have to deal with forests in all stages of development and intensity of management. Merely to teach them the current European techniques will only result in their frustration when they meet conditions to which they are not applicable.

A merit of this book is that it attempts to deal with this problem. While of necessity most of the book deals with European methods and conditions, it does so historically, and the special problems, particularly of tropical forests, now coming under systematic management for the first time are discussed. The special case of the United Kingdom, in so far as afforestation schemes are concerned, is mentioned but not developed. The student, however, should grasp that the type of management must be devised to meet the conditions prevailing, although the ultimate ideal may be the same everywhere.

The book is divided into three parts. Part 1 deals with basic considerations, such as the growing stock, increment, rotations, and the organization of the forest into different management units. Part 2 deals with the preparation of working plans. The general form and order is that suggested by the late Mr. Ray Bourne and now generally followed in Britain. All the usual methods of yield regulation are discussed. Brandis's method, first evolved in 1856 in Burma, is given a good deal of space, because it still has a place in some tropical forests. Brief reference is made to regulation by tending or cutting class as practised in Sweden. This might usefully have been developed more fully, because it has possible applications in similar forest types within the Commonwealth. Part 3 is entitled "Development of Forest Management in Western Europe". This is an interesting and concise review. Because, however, the same topics are in part discussed in both Parts 1 and 2, a good deal of forward as well as back referencing has been necessary, and in any future edition it would be worth while considering whether some rearrangement of the subject-matter would obviate this.

The book is designed primarily for the university forestry student; but it will require elaboration by his teacher in places. One defect is that there are no literature references, and at least a selected bibliography would have increased its value for this type of reader. The intelligent layman who wants to know about the problems of forest management will find this a useful book, because it is both lucid and readable.

H. M. Steven

UNDERWATER EXPLORATION BY 'AQUALUNG'

The Silent World

By J. Y. Cousteau with Frédéric Dumas. Pp. xi+148+65 plates. (London: Hamish Hamilton, Ltd., 1953.) 18*s*. net.

CAPTAIN COUSTEAU, who is at present leading an oceanographic expedition sponsored by the French Navy and the French Centre for Research and Oceanographic Studies, is a world authority on free deep-sea diving. With the development of his 'aqualung', a self-contained compressed-air unit with an automatic flow regulator, he has greatly enlarged the scope of underwater exploration and research with this apparatus, descents down to 300 ft. can be undertaken without the aid of any other special equipment or clothing.

Among the accounts in "The Silent World" of the varied investigations undertaken by Captain Cousteau

and his team of divers, of special interest are those relating to the exploration of the inland cave at the Fountain of Vacluse near Avignon; the surveys of numerous sunken ships in search of data on their biological incrustation; the effects of underwater explosions; and participation in 1948 in the preliminary trials of Prof. Auguste Piccard's 'Bathyscaphe'. Interspersed with these accounts are interesting comments on some of the physiological problems associated with diving, such as the effects of cold on the human body, on 'the bends', and the related nitrogen narcosis which produces deep-sea rapture (*l'ivresse des grandes profondeurs*).

Two valuable impressions emerge from reading this book, impressions which should encourage marine (and possibly freshwater) biologists to add this wonderful tool, the 'aqualung', to their research equipment. These are, first, the ease and degree of safety with which the equipment can be used, even by the non-swimmer, and secondly, the removal of at least some of the apprehensions and fears which intending divers may have about encounters with the traditional terrors of the deep, the barracuda, the giant rays, the octopus and even the shark.

In an epilogue to the book, the author answers the question which must have been put to him many times, "Why in the world do you want to go down into the sea?". Apart from being obsessed by a desire to explore the unknown, he believes that man must of necessity turn his attentions more and more to a study of the seas, to explore them intimately and draw sustenance in the form of minerals, chemicals and food from this vast, untouched 'cornucopia'. For this reason he urges the development of diving equipment capable of being used for exploring much greater depths than can his own 'aqualung', which he modestly dismisses as "primitive and unworthy of contemporary levels of science".

The book is lavishly illustrated with underwater photographs, many of which are in colour, and although essentially 'popular', it nevertheless contains much of interest to the hydrobiologist.

A. J. Brook

CALCULATING MACHINES

Les machines à penser

Par Louis Couffignal. Pp. 158+4 plates. (Paris: Le Éditions de Minuit, 1952.) n.p.

THE development of large and complex electronic computing machines naturally excites a great deal of popular interest. Words such as memory, decision, instruction, information and language are often used in descriptions of these machines. There are strong objections to the use of such anthropomorphic notions as that electronic digital computors possess rudimentary powers of scholarship, volition or reasoning (see, for example, Kapp, R. O., *Nature*, **170**, 547; 1952). But it really all reduces to the definitions used. The meaning of such definitions would be unnecessarily narrowed down and their pictorial power lost if processes like memory or reasoning were attributed solely to human beings.

Louis Couffignal is not afraid of using anthropomorphic terms, provided it is understood that the machines achieve the same ends by quite different means. The book opens with definitions of a machine and of thought. If one defines a machine as an assembly of objects which are put together in such a way that they replace man in the execution of a set of operations proposed by man, then, naturally, even the simple adding machine possesses a rudimentary memory and its mechanism of 'carry-over' replaces quite a complex set of mental operations of a human brain.

A description of adding machines and punched-card machines follows. It does not go into great technical detail of the machines themselves, but is sufficient to convey a general idea of their capabilities. The description of the universal machines deals with Babbage's ideas, with Mark I of Prof. Aitken, ENIAC, and a machine built at the Institut Blaise Pascal. The advantages of the binary system are clearly shown; its adoption leads to the reduction of the size of a large machine of a given capacity to about a third—a very considerable saving. The operations of multiplication, division and square-root extraction, using the binary system, are well explained. The next chapter is concerned with analogue machines, such as the differential analyser of Vanevar Bush; it is a pity that the electronic analogue machines, such as Pepinsky's X-RAC, are not mentioned.

The chapter dealing with the nervous system is rather superficial; one has the feeling that the writer is not in his own field here. Surely modern work on giant nerve fibres of squids and the permeability changes of the nerve membranes to potassium and sodium ions could have been included. The analogy between the transistor and a synapsis may not be as close as the author seems to believe.

In the chapter on the mechanization of logic the author, who is the director of the computing laboratory of the Institut Blaise Pascal, is much more in his element. The expression of logic in a binary system is of great interest, although rather heavy going for a lay reader. It took me some time to discover what the symbol 0010.0100 for a logic function (p. 105) really means and what is the significance of the dot in the symbol. Further confusion results from designations of "prédicats" P_n by a capital letter on p. 104, by a lower-case p_n on p. 112 and a capital in Fig. 25. Further, a function $p_n = 0000.1111$ on p. 109 has n as a subscript, and p^{n+1} on p. 114 has it as a superscript, without adequate explanation. However, these are only minor defects which do not detract from the value of the book as a suitable introduction to the subject.

The book finishes with, not conclusions, but a programme of research, stimulated by the close analogies between processes of human thought and modes of action of modern computing machines. There are no references and no subject index.

V. Vand

FOOD FOR THE WORLD

The White Man's Dilemma

Food and the Future. By Lord Boyd-Orr; with the co-operation of David Lubbock. Pp. 124. (London: George Allen and Unwin, Ltd., 1953.) 9*s*. 6*d*. net.

THE connecting link between the title and subtitle of this new survey of food problems by the first director-general of the United Nations Food and Agriculture Organization is the concept that food is

the foundation of social security and economic prosperity; that hunger has been the basis of most revolutions; and that hunger is at the root of the present revolt of Asia. Throughout the book runs Lord Boyd-Orr's strong conviction that there will never be world peace until there is no more hunger. The dilemma which he poses for the white man is the choice between attempting to maintain world military and economic supremacy, with the probable result of a disastrous world war which would end Western civilization, or using his present industrial superiority to develop the resources of the earth so as to end hunger and poverty, a course which would lead to the loss of the white man's world control gained by three centuries of conquest. As Lord Boyd-Orr says, this is a hard choice.

The section on world population trends quotes the already familiar estimate that this may increase from the present 2,400 to 4,000 million by the end of this century, but reaches an unusually optimistic conclusion that the limit will finally be set at between 4,000 and 6,000 million, after which world population will decline. Lord Boyd-Orr argues that the underdeveloped nations at present approaching the rapid population expansion experienced in England and Wales in the nineteenth century will, when their standard of living and education rises, begin the gradual decline in population growth now in progress in Western Europe. This leads him in his discussion on the agricultural potentialities of the world to the equally optimistic conclusion that "There seems no reason to doubt the estimate made by agricultural experts, that if modern improved methods were applied to all the land at present cultivated or grazed the world food supply would be doubled, and that if known measures were taken to increase the area of the earth under cultivation by irrigation, bush clearance, and other measures, the earth could support a population of 6,000 million". Before reaching this conclusion, he reviews the problem of soil erosion and the measures taken in the United States, U.S.S.R., China, Australia and elsewhere to overcome it and to promote irrigation. He also mentions some of the improvements which could be made by the use of fertilizers, the control of plant diseases, the use of seeds of high-yielding strains, selective breeding and improved management of livestock.

The chapter on the international attempts which have been made to solve the world food problem is a very useful reference. This, told by one who has made his own outstanding and original contributions in this field, describes, in particular, the work of the League of Nations leading to the concept of "The marriage of health and agriculture", and of the Food and Agriculture Organization.

The British food position is treated in an appendix which underlines its insecurity and suggests that a committee might with advantage be set up to consider long-term problems of food in terms of agriculture, trade and finance rather than politics ". . . to ensure that, say twenty years hence, there will be sufficient food, either imported or home-produced, for the people of the United Kingdom".

The section which traces the accumulation of knowledge on human nutritional requirements contains one misleading statement. Having explained that it was originally thought that hard physical work requires extra protein for replacement of wear and tear of muscles, the author does not state that subsequent investigation has not supported this assumption.

One detects and regrets a certain nostalgia that it was not possible "to throttle down science after the First World War, and to give human society a chance to assimilate and adjust itself to the new forces", but applauds the conclusion that it is urgent for politicians of all countries to get together "to consider how they can evolve a world order suited to the new age of science".

PROGRESS IN ANTARCTICA

The Antarctic Today

A Mid-Century Survey by the New Zealand Antarctic Society. Edited by Frank A. Simpson. Pp. 389+45 plates. (Wellington: A. H. and A. W. Reed; London: Phoenix House, Ltd., 1952.) 47*s*. 6*d*. net.

THE establishment of the Falkland Islands Dependencies Survey in 1943, fifty years after the first known landing on the antarctic mainland, marks a turning-point in the history of human endeavour in high southern latitudes. Although Bruce established a weather station in the South Orkneys in 1903, and handed it over to Argentina for permanent occupation, the need for scientific stations on the continent itself was not generally appreciated until long afterwards. Since 1943, however, the example of the United Kingdom has been followed by other countries with antarctic territorial claims, and the New Zealand Antarctic Society has performed a useful service by directing attention to the significance of recent developments.

The book is divided into seven parts, with chapters by different contributors. Especially useful are those dealing with glaciology, geology and oceanography, and with marine resources. It is unfortunate that N. E. Odell, who provides an excellent summary of the glaciology of Antarctica, was unable to benefit from the results of the recent Norwegian–British–Swedish Antarctic Expedition. These do not confirm the evidence that he adduces to suggest that a marked recession of the ice sheet is in progress. The geology of Antarctica is described by Rhodes W. Fairbridge. Only about 0·2 per cent of the total land area of 5,000,000 square miles is geologically known; but Mr. Fairbridge has succeeded in making a commendable analysis of the structure of the continent. Although he does not make the point, more details of the mineral wealth are urgently required, for conflicting territorial claims are not likely to be settled while so much remains in doubt. The difficulties of mining in rock covered by ice up to 6,000 ft. thick are not necessarily insurmountable.

The greatest mainspring of human activity in the Antarctic is the exploitation of marine resources, and about one-third of the text is given to various aspects of this subject. There are comprehensive accounts by C. A. Fleming of the physical oceanography and by R. K. Dell of the marine biology of the Southern Ocean, and W. H. Dawbin ably describes antarctic whales and whaling. British and Norwegian achievements in the task of maintaining stocks of whales are recognized, but Mr. Dawbin should also have mentioned Japanese work.

As P. G. Law points out, valuable results in the physical sciences can only be expected from continuous observations over a long period. As yet this work has only just begun, but the papers by A. R. Martin on meteorology and by J. W. Beagley on ionospheric research leave the impression that many more antarctic stations must be established before the problems connected with weather and atmospheric physics in the southern hemisphere can be solved. The importance of ionospheric research lies in the fact that trans-antarctic aviation is not likely to materialize, even if weather stations and airstrips are available, until radio communications are more certain. On the other hand, the expense of such investigations, and the sparseness of the population of the southern, compared with that of the northern, hemisphere may retard the development of far southern air routes for many years.

It seems a pity that the book contains no concise history of exploration, which is dealt with partly in the introduction and partly in the final chapter. The chapters dealing with recent field-work, and especially that compiled by the editorial committee, are out of proportion, and it would have been better to draw all the information together in a single chapter. A few minor points deserve mention. Most of the contributions have lists of references, but those by R. A. Falla, describing antarctic birds, and I. L. Thomsen, concerning auroral studies, have not. The first navigator to sight the mainland was not Biscoe in 1831, but Bransfield in 1820, and the first known landing was made by Larsen in 1893, not by Bull and Borchgrevink in 1895. The Society has regrettably not conformed to the practice of giving place-names in the local official form, or at least of giving this form in brackets. But these are slight blemishes of a fine book, which deserves to be widely read.

J. D. M. Blyth

RECRUITMENT OF AMERICAN SCIENTISTS

Origins of American Scientists

A Study Made under the Direction of a Committee of the Faculty of Wesleyan University. By R. H. Knapp and H. B. Goodrich. Pp. xiv+450. (Chicago: University of Chicago Press; London: Cambridge University Press, 1952.) 56*s*. 6*d*. net.

ANY problem arising in the United States concerning the origin of professional scientists is in some respects more troublesome than it would be in Britain, for whereas practically every student in Britain would enter an institution of 'similar' type offering up to a doctor's degree, an American student may commence his undergraduate work in a university or in a college (such as a liberal arts college) with no postgraduate degrees. In considering the need to increase the numbers of scientists, therefore, it may be necessary to determine what proportions of people have become scientists after commencing their studies in these different ways. Very broadly, reasons such as this stimulated the investigation which is described in this volume. The work was guided by a committee of the Faculty of Wesleyan University, with Prof. H. B. Goodrich as chairman.

One of the most serious difficulties that had to be faced was the selection of a suitable list or lists of scientists. Graduation was inadequate, for at that stage it may not be discernible what subsequent career is to be followed; this is much more likely to be true of American than of British students. After full consideration it was decided to use "American Men of Science", a publication which has now reached its eighth edition. It gives extensive lists of professional scientists, apparently showing some balance between the different sciences. There is, however, evidence to indicate that the methods of selection have tended to favour the inclusion of scientists in academic employment rather than those in industry, a discrimination which from the British point of view may reduce the value of much that follows. Taking this list, further reduced by selecting only scientists who hold the Ph.D. or equivalent degree (together with scientists who are 'starred' in that volume), some 16,000 were left. The college of origin was noted. The annual number of men graduates in science was obtained in all relevant institutions. Women graduates were ultimately omitted, partly because they form a limited part of the field, amounting to only around 2 per cent. Obviously a number of years must elapse between the date of first graduation and the completion of a research degree or the establishment of the individual as a professional scientist, and due allowance has been made for this lag. The investigation is therefore mainly historical, dealing with students who entered the university some time before the War; it does not purport to discuss conditions which would necessarily apply at the present time.

With these two values, the number of men science graduates and the related number of professional scientists, a basis of comparison (the productivity index) between different institutions is available. For example, listing the leading fifty institutions in the production of scientists, we find that the authors are able to include only five institutions at which there graduated annually, during the relevant period, more than two hundred, and of these two only could be called large universities. An interesting feature is the large number of liberal arts colleges in the fifty, devoted to fundamental scholarship rather than to specialized training. Only six are technological institutions. Nearly all the students of the latter concentrate on science, pure or applied; it is clear, however, that those who later follow a postgraduate course mostly do so in engineering, and if they undertake research in that field their interest is mainly technological and they have not been included in the list of scientists considered here. It may be noticed that a conspicuous position is occupied by the California Institute of Technology, which in many respects is different from other institutions specializing in technology.

The authors, it appears, have a chief interest in the education of 'pure' scientists, and this has to be remembered in reading all their conclusions. The British reader will learn a good deal about the smaller colleges. Several chapters are devoted particularly to small groups of colleges in which is given an account of the aims and achievements of individual institutions, of their history, and difficulties. For it is fully recognized that in their development they have been influenced by such factors as their geography, their finances, and their success or otherwise in obtaining men of the right type as teachers.

A. E. Trueman

Indian Epigraphy and South Indian Scripts

By C. Sivaramamurti. (Bulletin of the Madras Government Museum, New Series, General Section, Vol. 3, No. 4.) Pp. viii+280+133 text figures+12 plates. (Madras: Government Press, 1952.) Rs. 14-8-0.

THE author of this publication, who is already well known for his work on "Amaravati Sculptures in the Madras Government Museum" and as co-author of "Guide to Archæological Galleries" and "Illustrations of Indian Sculpture", is at present superintendent of the Archæological Section of the Indian Museum at Calcutta. His painstaking research in the field of epigraphy has been collected in the present volume.

The work is a valuable contribution to the study of Indian epigraphy, which is a necessary adjunct to the study of ancient Indian history, culture and ethnography. It is of special concern to those who are interested in the question of the evolution of the various Indian alphabets from a common source. The Indian subcontinent, with the possible exception of Kashmir and Assam, is generally deficient in an old historical literature. The innumerable inscriptions, copper plates and coins scattered all over the country partially fill this void. In his introductory chapter the author has discussed the value and need of studying this oft-neglected subject.

Mr. Sivaramamurti has drawn charts showing "the development of each individual letter of the Indian alphabet in different areas and during centuries in different types of script developed from the same parent stock" (p.viii), with emphasis on the development of the South Indian alphabet. He rightly remarks that "The scripts of South India have contributed enormously to the spread of Indian culture overseas" (p. 55). The truth of this statement is borne out by the conclusion which he has arrived at by the diligent comparative study of the epigraphy of those regions. He states: "The script of Ceylon is derived from Grantha Tamil. The script of the inscriptions in Java like those of Pūrnavarman closely resembles the early script of South India. The same applies also to the characters used in the inscriptions of Annam or Campa" (p. 55).

In Plate I the author has placed the regional alphabets from various areas, including East Turkestan, Tibet, Ceylon, Burma, Annam, Malaya, Java and Borneo, side-by-side to facilitate a comparison of the individual characters. Here one misses the area comprising the north-eastern corner of India. Inclusion of scripts from inscriptions in Orissa, Bengal and Assam would have provided, in my opinion, a better perspective for a comparative study.

The author is to be congratulated on his valuable contribution to the study of Indian epigraphy.

M. C. Goswami

Timber Progress and Desk Book for 1953

Edited by W. E. Bruce. Pp. 202. (London: Cleaver-Hume Press, Ltd., 1952.) 15*s*.

THE objective of "Timber Progress" is to record annually in authoritative, independent, easy-to-read articles the new ideas, new movements and latest achievements in the technology and commerce of the timber and allied industries. In a foreword David Irwin, chairman of the Education Standing Committee of the Timber Development Association, states that "this publication fills a long-felt want, containing as it does a series of articles by recognized authorities, a most comprehensive bibliography on timber literature and other useful reference items. It is a library in itself and will, I feel sure, be welcomed by student and employer alike".

Among the articles may be mentioned the following: some recent changes in timber trade practice; structures of new timbers; world review of the newer timbers and their commercial uses; moisture in wood and modern methods of seasoning; British-made plywood and its possibilities; development of modern furniture design in Britain; principles of conversion; and a reference section.

This little book furnishes evidence of the enormous increases in the imports of previously unknown timbers from tropical and sub-tropical forests. In connexion with South-East Asia, it is said that before the Second World War this part of the world provided certain specialized woods only, the most famous being the genuine Burmese teak which is to-day so scarce and expensive. In addition were imported some of the decorative woods such as satinwood, rosewood, pyinkado and gurjun. During the later years of the past century and the early years of the present one before the First World War, Indian forest officers made considerable efforts to place on the London or other British timber markets some of the fine species of Indian timbers, but they met with practically no success. The position of these tropical and sub-tropical timbers is very different nowadays. But much practical research has yet to be carried out before their utilization as a commercial proposition has been substantiated: the forests and their distribution in their habitat; the types of forests in which they are found, and in a mixed forest their proportion in the mixture per acre or hectare or square mile; and the accessibility for extraction at an economic cost. E. P. Stebbing

General Chemistry

An Elementary Survey emphasizing Industrial Applications of Fundamental Principles. By Prof. Horace G. Deming. Sixth edition. Pp. xii+662. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1952.) 46*s*. net.

THIS much-used text-book is an introduction to chemistry for university students including those not continuing its study. Prof. H. G. Deming presents the achievements of chemistry and its great economic possibilities not as attractions in themselves but as spurs to study a science worthy of, and requiring, considerable effort. His course follows no definite syllabus but covers approximately the requirements of the Intermediate B.Sc. of a British university, with some additions. These include a chapter on nuclear chemistry and four on organic chemistry, respectively, entitled as follows: hydrocarbons; alcohols, esters, carbohydrates; cellulose products and plastics; and elastomers, dyestuffs and medicinals.

Although Prof. Deming has the remarkable gift of finding simple explanations of difficult matters, his treatment is thorough. He expounds the physical basis of the chemistry in question, stresses the significance of structure and makes advantageous use of present-day knowledge and ideas. Besides the skilful expositions, the student is afforded an abundance of help by the interpolated questions, exercises, cross-references, informative illustrations and summaries for revision. Good as the earlier editions were, the present effort, the product of the author's ripe experience, is even better.

G. F.

Historical Aspects of Organic Evolution

By Dr. Philip G. Fothergill. Pp. xvii+427. (London: Hollis and Carter, Ltd., 1952.) 35*s*. net.

THE subject-matter of this book is exactly indicated by its title: it gives a historical account of the initial and changing conceptions of organic evolution from ancient times down to the present period of manifold observation and experimental investigation. There can be no doubt that this book will prove of interest and value to all who maintain either a general or a particular interest in scholarship germane to this major biological theme. The book is concisely comprehensive and, not least important, it is lucid and readable. In the first part the author traces the historical development of the idea of evolution, beginning in the remote and obscure Chinese, Babylonian and Egyptian periods, and culminating in the post-Darwinian period when evolution had become generally accepted as an established principle.

The second part deals with cytogenetics and modern causal theories of evolution. In this part, the rediscovery of Mendelism, chromosome studies and gene theory are considered. Finally, in the concluding chapters, there is a survey of the various recent theories of evolution, including neo-Lamarckism, neo-Darwinism and the views of particular exponents such as Lotsy, Willis and Goldschmidt. Various special subjects are dealt with in some eight appendixes. This book may be generally recommended as being likely to retain for many years to come its usefulness both as a valuable and readable text and as a work of reference.

Heat Transfer Phenomena

The Flow of Heat in Physical Systems. By Dr. R. C. L. Bosworth. Pp. xii+211. (Sydney: Associated General Publications Pty., Ltd.; London: Pergamon Press, Ltd.; New York: John Wiley and Sons, Inc., 1952.) 42*s*. net.

MOST books on heat transfer are written from the point of view of the engineer and contain relatively little discussion either of the nature of the underlying physical processes (for example, the mechanism of conduction) or of the relation of the subject to other branches of physics. Dr. R. C. L. Bosworth's survey is therefore particularly welcome because he lays especial emphasis on these aspects of heat transfer. Throughout the book he brings out the similarities and differences, quantitative as well as qualitative, between the transfer of heat, momentum, electricity, matter, etc. Particularly illuminating is the comparison between thermal radiation and conduction in gases with a long mean-free-path. The well-known 'electrical analogy' is considerably developed, and the existence of 'inductance' as well as 'capacitance' in thermal processes is pointed out.

In addition to tracing the main outlines of the subject in a concise manner, the book contains a good review of the most recent work on conduction, convection and radiation, including the technique of measurement, and gives extensive lists of references. Although some casual statements may be criticized—for example, that forced convection only outweighs natural convection when the flow is turbulent (p. 113)—and although misprints are rather unusually numerous, the book will be of lasting value to students and research workers. Only the purists among them will hesitate to accord full agreement to the publishers' prefatory claim that the book "satisfies a much needed want".

The Sky and Its Mysteries

By Ernest Agar Beet. Pp. 238+15 plates+56 figs. (London: G. Bell and Sons, Ltd., 1952.) 15*s*. net.

IN writing this book for the non-specialist, the author has preserved a sense of balance by devoting by far the greater portion to the solar system, a description of some of the more important instruments used by the astronomer, and a short historical sketch up to about the end of the past century. Mathematical treatment of the subject has been almost entirely eliminated, which will enhance its interest and value for many beginners; while there is little new in the text, the manner of presentation is very lucid, and it is certain that the book will make a strong appeal to many amateur astronomers. The map at the end may seem a weak point in the work; but, as the author points out in the preface, "it is to supplement, not to replace, the normal kind of star map for outdoor use". A list of periodicals supplying information on the night sky, month by month, is given on p. 229, one an American publication and three British; but it might be suggested that some additional British publications should be referred to in a future edition—especially those which describe the times of the rising and setting of the planets. A few points require slight amendments in the revision as, for example, the statement on p. 121 that Mars is at its nearest when fully illuminated, and that on p. 138 regarding the sporadic meteors with hyperbolic velocities, and some others; but these are very minor points which do not detract from the value of this excellent book. M. D.

Puffins

By R. M. Lockley. Pp. xi+186+17 plates. (London: J. M. Dent and Sons, Ltd., 1953.) 18*s*. net.

MR. R. M. LOCKLEY has added an interesting volume to the fast growing list of bird monographs. His long residence on the island of Skokholm and his intimate acquaintance with the large puffin population of the Pembrokeshire islands qualifies him for the task of writing on *Fratercula arctica*. He does so both informatively and entertainingly, most of what he tells us being the result of long periods of puffin-watching on the islands of Skokholm and Skomer, particularly the latter, where he estimates at least 50,000 pairs bred in 1952. His book deals with the puffin from the time it returns to its breeding haunts in early spring until the last deserted young one goes off to sea. In addition, the author has chapters on the "Mind of a Bird", the "Winter Ocean" and "Man and Puffin", with appendixes on "Numbers", "Distribution", "Recoveries of Ringed Puffins", etc. Under the heading of "Numbers" he tries to estimate the total population of *Fratercula arctica* and thinks it may be (including the sub-species *F. a. naumanni* of Spitsbergen, *A. a. arctica* of north Norway, Iceland and North America, plus *A. a. grabæ* of Britain, the Faroes and France) between fifteen and sixteen millions of birds. But he adds a word of warning, saying it is "clear that the present figure is a reduction, probably a considerable one, on the population of one hundred years ago". However, he concludes by saying that, "still the puffin remains one of, if not the, most numerous of seabirds in the whole Atlantic".

FRANCES PITT

RELATION OF RELIGION AND SCIENCE

By the Very Rev. W. R. MATTHEWS, K.C.V.O.
Dean of St. Paul's Cathedral

THE problem of the relation of religion and science is not dead, as we are often told, but has been made obscure because it has become difficult to define the issue clearly. In the days of T. H. Huxley and Gladstone it was comparatively simple. The Christian religion asserted a great number of propositions which it held to be true, while science, or scientific researchers, had come to conclusions which seemed, in many cases, to be irreconcilable with those propositions. Now, however, the epistemologists have raised the question of the nature of scientific 'truth' and the still more devastating question whether religious propositions have any meaning and can be described as either true or false. The consequence is that discussions of religion and science tend to degenerate into a kind of shadow boxing: neither side of the argument really comes to grips with the other. Yet the 'plain man' feels that there is a problem and a vital one. In his simple way, he would say that the kind of universe which science progressively discloses is singularly unlike the kind of universe which is presented by the documents and the doctrines of the Christian faith.

It is one of the many merits of Prof. Coulson's recent book that he is quite clear on what he is talking about*. By science he means the results, up to date, of the application of the scientific method in every sphere where it has been applied and the method itself; by religion he means the Christian religion, not as a vague sentiment or an admiration for the character of Jesus, but as a system of doctrine and worship. Nor is there any doubt about the purpose of his inquiry. It is, "To see whether there is any coherence between science and religion, and whether, in an age of science, it is possible to hold the faith with propriety and with intellectual integrity".

This little book, consisting of three lectures given under the Riddell Memorial foundation, contains more sound sense on the subject than most works five times its size, for it deals with the ultimate issues and keeps to the point. The challenge of the two universes and two systems of knowledge—the scientific and the religious—is always before his mind. He rejects any theory which would vindicate religion by somehow inserting it into the scientific universe, finding a place for it either in the yet unexplored territory or in the incoherences which can be discovered in scientific conclusions. Perhaps he is a little too hard on theologians who find something of interest to them in Heisenberg's uncertainty principle, for if determinism breaks down in one part of Nature, it may well be only an appearance, or a useful fiction, elsewhere; but undoubtedly he is splendidly right when he says, "If God is here at all, it must be at the beginning of science and right through it".

The concept of Nature inevitably comes up for discussion. Prof. Coulson rejects the idea that Nature is 'given', in the sense that it lies 'out there' presenting us with a puzzle to be solved. In a very general way one may agree that his view of Nature is Kantean. Certainly he holds that, in a sense, "mind makes nature", and that it is totally misleading to assume that we have any knowledge of Nature, or of the existence of Nature, apart from our minds. In some of his phrases he seems to go beyond Kant and to verge on Berkeleyan idealism; but on the whole, he holds fast to the conviction that, though in one sense "the whole scientific universe is a construction of our own", in another sense, it has objective validity, though it is not easy to gather from these lectures precisely what this latter sense can be. But, after all, Kant himself left us in the dark about the "things in themselves".

The short answer to the question, why there can be two different views of the universe, the religious and the scientific, both well-founded, is that they are two distinct views of the same object. This thought is developed with great skill by means of an analogy —that of the different aspects of Ben Nevis. This might easily have been too facile a solution; but Prof. Coulson is careful to point out where his analogy fails, and perhaps the reader would be well advised, in reflecting upon this conception of two points of view, to bear in mind the important passage at the end of Lecture 1, where it is argued that Nature and man are indissoluble and that Nature has a spiritual meaning. In this connexion the author has a word for theologians as well as for scientists. Too often, he thinks, theologians regard Nature as merely the stage on which the great drama is performed, whereas they ought to think of it as a part of the play.

One difficulty may be mentioned about the 'aspect' or 'point of view' theory. It would certainly be more convincing if there were only one religion; but the great religions of the world differ in a marked degree from one another in their conceptions of the universe, of the ultimate Reality and of man's place in the whole, yet presumably both the Buddhist and the Christian systems arise from the religious apprehension of the One Object. Two possible answers suggest themselves to this objection. It might be maintained that there is, in fact, a fundamental agreement beneath the differences of the great religions, and it might be argued too that there is, in fact, no settled scientific view of Nature. In both spheres, so to speak, there are shifts of focus.

It is not possible to touch upon all the lines of thought which are opened up by this suggestive book; but we must not omit one which evidently is very near Prof. Coulson's heart, the 'message' which he would give to theologians and scientists alike. It is that we should enlarge our idea of the life of the Spirit. The work of scientific research, when faithfully done, is a spiritual activity and a service of God. All the disciplines which constitute culture are, in essence, spiritual, and each needs all the others. The ideal of the Christian Church is a fellowship of all who 'wonder'—the scientist, the historian, the poet and artist, the philosopher and theologian, and also the unlearned man of faith. In this fellowship "the fullness of each separate discipline is revealed". In such words we welcome the authentic voice of Christian humanism.

* Christianity in an Age of Science. By Prof. C. A. Coulson. (Riddell Memorial Lectures, Twenty-fifth Series.) Pp. ii+53. (London: Oxford University Press, 1953.) 5s. net.

THE ITALIAN NATIONAL SCIENCE MUSEUM AT MILAN

By W. T. O'DEA
Science Museum, London

THE museums of Italy are at a most lively stage of development. During the War they suffered heavy damage; but rebuilding has proceeded at a pace that makes progress in Britain seem very inadequate by comparison. The result of rebuilding, re-design and re-organization has been a sharp rise in attendances from 800,000 in 1946 to 4,725,000 in 1952 at national museums. This figure is nearly double the highest pre-war number of visitors in a year (1937) and applies, naturally, to art museums in the main. There is, however, one striking example of the way science has shared and is to share in these developments.

The National Museum of Science and Technology at Milan is housed in buildings which follow the plan of the badly war-damaged early sixteenth-century Monastery of San Vittore. Leonardo's "Last Supper" was painted a few years earlier only a short distance away and he was still working in Milan when the Monastery was built. The man who, above all others, combined mastery in sciences with mastery in the arts is therefore specially honoured in this new Museum. The display of models to celebrate the fifth centenary of the birth of Leonardo da Vinci has already been described and most of the models are replicas of those built in Italy, exhibited there in 1939, taken to New York in 1940, and destroyed by fire in Tokyo during the War. It will therefore suffice to say that these models are built with a genuine feeling for the methods and materials of the time, are very well set out, and are to such well-chosen sizes that the aeronautical items, for example, really do look as though they might take to the air without breaking up. Leonardo's sketches were not dimensioned, so that interpretation becomes most important when building models to his ideas. In a few cases, such as excavators and cranes, Leonardo's original suggestions are shown in model form with models beside them to show the not so very dissimilar (making allowances for a five-century interval) modern counterparts.

So far the Museum is in a very early stage of development, although representatives at the third International Conference on Museums held in Milan this year were greatly impressed with what had been done, so quickly, under the guidance of Dr. Guido Ucelli. The Leonardo exhibits predominate, with another important gallery displaying an attractive collection of models of warships, merchantmen and small craft as the Italian Naval Museum. A start has been made on a section to illustrate the history of aeronautics; but this can scarcely be more than a token until a new arch-roofed building, the frame and most of the walls of which are now to be seen, is completed. Here the aeronautical collections of the Italian Army, at present stored in Rome, are to be set out by Captain Soldatini, who has already been responsible for the instruments of warfare in the Leonardo Collections.

Extensions are also being built at the present time to include a cinema for scientific films and a library of the history of science, to which Dr. Ucelli will contribute his own extensive collection of books. There already exists a reading room in which many technical periodicals are regularly received.

At the present time about two thousand visitors go to this new Museum every week; but it is to be expected that much greater numbers will attend as the collections develop. The support of industry has still to be obtained before many projected new sections can be planned on an adequate scale. There is little doubt that this will be forthcoming eventually, and in that respect the wisdom of actually opening the Museum to the public is incontestable. Ships, aeroplanes and Leonardo da Vinci happened to be the three subjects on which sufficient material or impetus existed. For future developments much will depend upon which industries react most favourably to the suggestion that they should contribute both in material and in finance for display. The fact that there are now an embryo but effective Museum and already an interested public should be of the greatest assistance in influencing such potential benefactors.

The Museum buildings themselves are worthy of comment. The damage to the sixteenth-century Monastery (itself on the site of an older monastery, which in turn occupied a site on which there can still be seen remains of a Roman wall) was of so fundamental an order that the present buildings may practically be described as new. Such skilful use has been made of new materials that the monastic atmosphere remains; and yet an impression of modernity is conveyed at the same time. The Leonardo Gallery on the first floor has a high arched roof and looks, from its length, not unlike a cloister in some respects. Yet the display of Leonardo models is modern and attractive. Each model is on a table made by bending and toughening a long

Fig. 1. View of the large conference hall where the display from the International Conference on Museums is arranged

Fig. 2. View of the first cloister. Foreground : remains of ancient Roman walls

rectangular sheet of plate glass. A concealed fluorescent lamp lights each model and the only daylight comes from a few small circular windows up near the ceiling. The finish of walls and ceiling is of whitewash. The result is a well-graded illumination and no violent contrasts to disquiet the eye such as the transition from, say, 10 candles/sq. ft. on an exhibit to a brightness of 2,000 candles/sq. ft. or more from the sky seen through a window as soon as the eye is lifted. Unrestful contrasts of this order are common in most museums, and it is very pleasant to go around galleries such as these in Milan where violent brightness transitions are avoided.

This Science Museum in the making is worthy of great support, and its development should be very interesting to watch. In connexion with the International Conference on Museums a series of more than a hundred panels of photographs were contributed by more than twenty museums of science and technology throughout the world to illustrate their techniques and achievements. These are displayed around the principal lecture theatre in the Museum, and Dr. Ucelli hopes to retain them for some time to help him to show what other countries are doing and to obtain further interest in his own plans. In these he will have the best wishes of everybody in the museum world and should attract the support of both science and industry.

SIZE EFFECTS IN THE INITIATION AND GROWTH OF EXPLOSION

By Dr. F. P. BOWDEN, F.R.S., and K. SINGH

Research Laboratory for the Physics and Chemistry of Surfaces, Department of Physical Chemistry, Cambridge

THERE is a good deal of evidence that the initiation of explosion by impact and by friction is, commonly, thermal in origin[1]. The mechanical energy of the blow or of rubbing is degraded into heat and concentrated to form a small 'hot spot'. These hot spots, though small, are large compared with molecular dimensions. Their size, as we should expect, is very dependent upon the experimental conditions ; but they may range from *c.* 10^{-5} to 10^{-3} cm. in diameter, and their duration[2] may be short, for example, 10^{-5} sec. With many explosions the necessary hot-spot temperature may be *c.* 400° C.–500° C. These hot spots are readily formed in two main ways : (1) by the adiabatic compression of small included gas bubbles ; the presence even of a single tiny bubble can render most explosives extremely sensitive to impact ; (2) by friction on the confining surfaces, on grit particles or on crystals of the explosive itself. Under very extreme conditions, a sufficient rise of temperature can be produced by a viscous heating of the rapidly flowing explosive, but this normally requires a very high impact-energy.

On this thermal mechanism, we should expect that the growth of a small explosion from a hot spot to one of finite dimensions would be governed by simple physical considerations. If the rate of evolution of heat by chemical reaction within the small volume is greater than the rate at which it is lost to the surroundings by conduction and other means, it will grow ; if not, it will die away. The general treatment of this has been given by a number of workers[3]. Calculations for some solid and liquid high explosives[4] show that for a hot-spot temperature of 400°–500° C. the minimum size is in the range 10^{-3} to 10^{-4} cm. diameter. This is in agreement with our measured values.

Irradiation with Electrons and Neutrons

We have recently made some further studies of hot-spot size in initiating explosives by irradiating the explosive crystals with beams of electrons and neutrons, and also by heating very small crystals. It has been suggested[5] that the simultaneous decomposition of two adjacent molecules of lead azide could lead to explosion. Kallmann and Schrankler[6] have observed the initiation of T.N.T., mercury fulminate and azides when bombarded with an intense beam of hydrogen, argon and mercury ions. They have suggested that the explosion is due to the activation of a few neighbouring molecules. Muraour[7] has also observed the explosion of silver acetylide when irradiated with high-speed electrons, and explained the result in a similar way. We find that when crystals of lead azide are irradiated with an electron beam of 75 KeV. and 200 μamp., explosion occurs. It was thought, however, that this and the explosion reported by other workers might be due to a bulk heating of the explosive. The explosive was, therefore, replaced by crystals of potassium nitrate (melting point, 334° C.). These were readily melted in the electron beam, showing that the temperature rise was greater than 334° C. This and additional experiments on the fusion of metallic wires provide strong evidence that the explosion of the azide under these conditions can be due to bulk heating.

In order to avoid this bulk heating, the explosive crystals were bombarded with slow neutrons (flux, 10^8 neutrons per cm.^{2} per sec.). The experiments

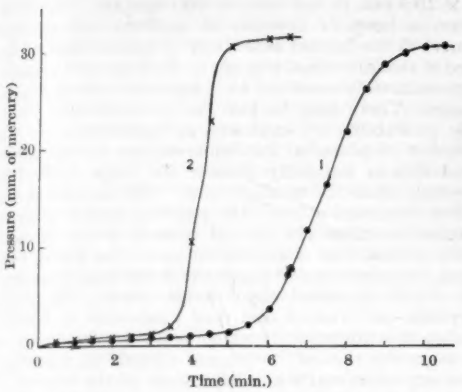

Fig. 1. Influence of neutron irradiation on thermal decomposition of lithium azide: (1) unirradiated; (2) after irradiation. Temperature, 250° C.; pressure, 10 cm. mercury

were carried out with cadmium azide, lead azide, silver azide, silver acetylide and lithium azide. In no case did explosion occur, although interesting changes were observed in the crystals. In a second series of experiments, the crystals of lead azide and cadmium azide were mixed with uranium oxide and irradiated with neutrons so that fission of uranium-235 took place. Again no explosion occurred. In these last experiments, the energy of the fission products is *c.* 94 MeV. and the range of these particles in lead azide is *c.* 10^{-3} cm. It is clear that irradiation of this kind could produce the decomposition of a large number of adjacent azide molecules, but it does not cause explosion.

If we assume that the energy is dissipated along the track of the particle to form a 'hot cylinder' equal to its length, and of a temperature of 400° C., the diameter of this cylinder would be about 2×10^{-6} cm. This did not cause explosion even when the crystals were maintained at 290° C. during irradiation. Irradiation with α-particles and γ-radiation also failed to cause explosion.

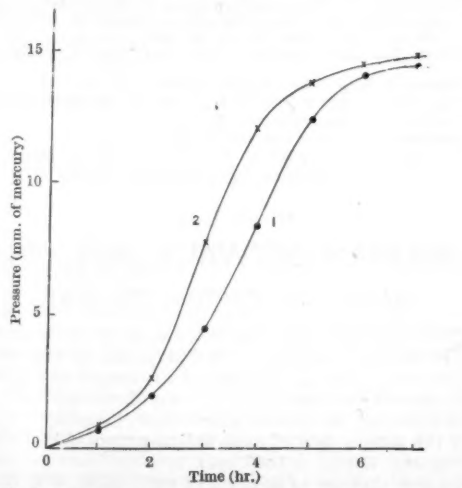

Fig. 2. Influence of neutron irradiation on thermal decomposition of lead azide; (1) unirradiated; (2) after irradiation. Temperature, 281° C.

Fig. 3. Influence of crystal size on explosion. Cadmium azide (*a*) before heating, (*b*) after heating at 320° C. for three minutes. The largest two crystals have exploded, the smaller ones decompose slowly

The only exception we have so far observed is nitrogen iodide, which does explode when irradiated by neutrons. However, Meldrum[8] has shown that nitrogen iodide will explode at room temperature if ammonia is removed from the surface.

Although neutron irradiation under these conditions does not, in general, cause explosion, it does produce interesting changes in the crystal. Colour changes and darkening, indicating the formation of *F* centres and nuclei, are observed. This affects the subsequent course of the thermal decomposition of the explosive. This is illustrated in Figs. 1 and 2. With lithium azide, the induction period is reduced to about one-half and the rate of decomposition is considerably increased. With lead azide the thermal decomposition is also accelerated.

Influence of Crystal Size

If azide crystals of different sizes are arranged on a glass plate and placed in a furnace at a fixed temperature, it is found that crystals above a certain size explode, whereas those below the critical size decompose slowly. This is illustrated for cadmium azide in Figs. 3*a* and 3*b*. The critical size appears to be determined by the smallest dimension of the crystal; for example, its thickness if it has a plate-like structure. The critical size is dependent upon temperature, and some typical values for cadmium azide are given.

Temperature (°C.)	Critical size
320	24×10^{-4} cm.
325	20×10^{-4} cm.
330	17×10^{-4} cm.

It is interesting to see that this critical size, of a few microns, is similar to the hot-spot size measured in other ways. Analogous effects were observed with crystals of α-lead azide and silver azide. If the crystals are below the critical size, or if larger crystals are heated at a lower temperature so that only thermal decomposition takes place, the crystals split and break up along crystallographic planes. This is illustrated in Fig. 4*a* for cadmium azide and in Fig. 4*b* for α-lead azide. This suggests that the rate of decomposition may be a maximum along preferred planes within the crystal. The decomposition involves the formation of metallic nuclei and the evolution of gaseous nitrogen, accompanied by a large amount of heat, and this may easily lead to a splitting of the crystal. This splitting can occur with violence. The spreading of the dislocations and cracks through the crystal may play a part in the propagation process.

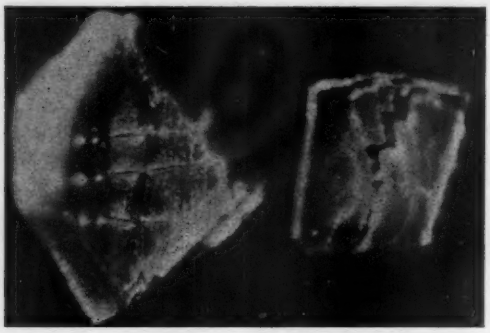

Fig. 4. Crystals of cadmium azide (*a*), and α-lead azide (*b*), which are decomposing thermally. Note cracking and splitting along crystal axes

It will also influence the rate of thermal decomposition by exposing a large amount of fresh surface.

Crystal Size and Impact Sensitivity

(with A. M. Yuill)

From similar considerations we may expect that the impact sensitivity of a crystal will be dependent upon its size. If the crystal is too small, the reaction will not be able to grow to explosion and the initiation will then, apparently, be unsuccessful. Mr. A. M. Yuill has investigated the effect of crystal size on the impact sensitivity of lead azide. Single crystals of the azide were placed on an anvil and struck with a flat-faced hammer, using an apparatus described elsewnere. The results are illustrated in Fig. 5.

Curve 1 is for individual crystals, and it will be seen that below a certain size the impact sensitivity is very dependent upon the size of crystal. For a crystal of 8×10^{-3} cm. in size, the impact energy for a 50 per cent probability of explosion is *c.* 5 kgm.cm.; as the crystal size is decreased, the necessary impact energy increases, and with a crystal of about 1×10^{-3} cm. it has risen to 200 kgm.cm. If, however, a heap of crystals of uniform size is used (curve 2) the impact sensitivity is independent of the size of the individual crystals in the heap and remains approximately constant at 2 kgm.cm. over this size-range. There may be two factors involved. First, the probability of explosion is determined by the number of potential initiation centres or hot spots, and this is naturally greater for large individual crystals than for smaller ones. The second is the effect discussed above: the reaction cannot grow to explosion unless the crystal exceeds a critical size. This critical size is dependent upon the initial hot-spot temperature and hence upon the impact energy. It should be noted that, under impact, the single crystals are crushed and flow plastically to form a pellet the thickness of which is about one-tenth to one-quarter that of the original crystal. If, therefore, the explosion starts at a late stage of the impact, it may be this thickness which is the limiting factor.

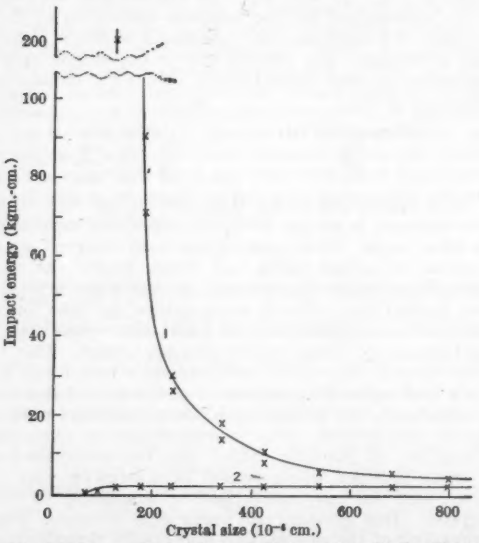

Fig. 5. Influence of crystal size on the impact sensitivity of lead azide; (1) single crystals; (2) heap of crystals

These experiments provide strong evidence that the explosion nucleus must exceed a critical size (which is quite large and is determined primarily by thermal considerations) before it can grow to detonation. Earlier work[1] has shown that, in addition to being a precarious process, the growth can be complex. For many explosives it begins as a comparatively gentle burning which accelerates to a few hundred metres a second before passing over into detonation, and the successful growth of the explosion requires critical conditions. The propagation of the low-velocity detonation is itself assisted by air bubbles and other sources of local hot spots[9]. The chemical reactions occurring during this burning phase are different from, and less complete than, the decomposition in detonation[10]. With metallic azides this intermediate burning stage is not observed. Very frequently, in sensitivity tests and in practical operation, the failure of an explosion to take place is due, not to a failure in initiating the reaction, but simply to a failure in the growth process.

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WILHELM OSTWALD (1853–1932)

By Prof. J. R. PARTINGTON, M.B.E.

SEPTEMBER 2 is the centenary of the birth of Wilhelm Ostwald (1853–1932), one of the most influential physical chemists of the second half of the nineteenth century. His own investigations of chemical equilibrium convinced him of the importance of the general law of mass action proposed by Guldberg and Waage in 1867, and from 1887 he welcomed the new theories of solution of van't Hoff, of electrolytic dissociation of Arrhenius, and of galvanic cells of Nernst. Ostwald introduced chemists to the use

of thermodynamics (which he tried to simplify in his system of 'energetics'), and was the first to emphasize the importance of the little-known publications of Gibbs and the value of the phase rule. These aspects of physical chemistry led him to under-estimate the importance of the atomic theory, but he recognized its significance after the work of Perrin on fine suspensions, and the discovery of radioactivity, had given it what he regarded as an experimental foundation. His own work on catalysis had led him to formulate the main features of the phenomenon in a manner which emphasized the observed facts and minimized the unverified (or unverifiable) and unnecessary hypothetical interpretation of them. This method of approach was typical of his outlook.

In his time, Ostwald was an international authority and his influence was comparable with that of Berzelius in an earlier generation. Many chemists, before adopting or using new theories, waited first to see what Ostwald would say about them and to what form he would reshape them to suit chemical requirements. His books, especially the smaller "Outlines of General Chemistry" and its many translations, were a powerful stimulus to the study of the newer physical chemistry, and his influence can be traced to-day in many directions, although its origin may not be adequately recognized. He was pre-eminently a clarifier and systematizer of knowledge, and an indefatigable defender and exponent of the newer physical chemistry based on the theories of solutions and electrolytic dissociation. His insistence that physical chemistry is a study equal in rank to any other branch of chemistry was necessary and important. Whole branches of chemistry now taught as commonplaces won their way into the science only after prolonged battles against either determined opposition or studied indifference. In maintaining their claims, Ostwald was much to the fore.

Ostwald was a man of many interests, in literature, music and art as well as in science. He devoted much time to the development of a colour scale and of an international language. He was greatly interested in the history of science and founded the "Klassiker" series. He believed that a historical approach had a disciplinary value. His many pupils venerated him and his influence in physical chemistry was fruitful and beneficial in many ways. It can be said with truth that physical chemistry owes very much, both directly and indirectly, to the research and teaching of Ostwald.

OBITUARY

Prof. F. H. Rein

THE death of Prof. F. H. Rein occurred at the age of fifty-six on May 14, at Göttingen, where he had occupied the chair of physiology from 1931 until 1953. He had recently resigned on his appointment as director of the Max–Planck Institute for Medical Research in Heidelberg, but had not actually taken up his new post.

Rein's scientific work consisted mainly in the application of ingenious physical and mechanical principles to physiological problems, and among the results of this work were the 'Thermostromuhr' and the 'Stoffwechselschreiber'. The 'Thermostromuhr' has since been criticized, and certain of its limitations have been shown; but in Rein's hands it made possible the investigation of many problems of the circulation as shown by the long series of publications from his Institute. It was a tragedy that Rein reached the peak of his ability when the position in Germany was becoming unfavourable for scientific work, and when international scientific relations were becoming difficult and finally impossible. When he gave a series of lectures in London in 1937 on the relation between metabolism and blood flow, he greatly appreciated the contact with English workers and was deeply concerned with the increasing difficulty of getting more interchange between Great Britain and Germany. The complete separation of the two countries during 1939–45 was followed by a great increase in the growing tendency in Britain to look to the United States rather than to the Continent for scientific exchange. This combination of circumstances has made Rein's work less widely known and appreciated in Britain. In addition to his numerous original papers he wrote a "Text Book of Physiology" which reached ten editions and is widely used in Germany. He was also senior author of the Physiology Section of the Fiat Reviews of German Science during 1939–46.

In his private life Rein was undemonstrative and somewhat reserved; but he inspired an intense loyalty in his younger colleagues, a number of whom now occupy chairs of physiology in Germany and elsewhere. Beneath his reserve he was extremely friendly, and he and his wife entertained the workers and visitors at his Institute with a kindly hospitality. His services to the University at Göttingen were great. He was responsible for the new Institute of Physiology which was completed in 1938. After the War he acted as rector of the University at a very difficult period, and he did much for the rehabilitation of the University. He was also one of the founders of the Fridtjof Nansen House in Göttingen, which was a centre for international student activities.

D. H. SMYTH

NEWS and VIEWS

Royal Aeronautical Society: Medal Awards

THE following Medals have been awarded by the Royal Aeronautical Society and will be presented at a meeting at the Royal Institution, London, on September 14: *Society's Gold Medal*, which is the highest honour that the Society can confer, to Mr. E. F. Relf, for his outstanding contribution to aeronautical science over a period of many years; *Society's Silver Medal*, to Mr. H. Grinsted, for his outstanding work in aeronautical engineering; *Society's Bronze Medal*, to Mr. L. Boddington, for his work on the development of naval aircraft; *British Gold Medal for Aeronautics*, to Mr. R. E. Bishop, for his outstanding contribution to aircraft design; *British Silver Medal for Aeronautics*, to Mr. J. E. Gordon, for his excellent work in the sphere of aircraft structural plastics; *Wakefield Gold Medal*, to Mr. F. W. Meredith, for his work in the design of automatic pilots and aircraft instruments; *Simms Gold Medal*, to Major P. L. Teed, for his paper on "Fatigue of Aircraft Materials with Special Reference to Micro-Structure"; *George Taylor (of Australia) Gold Medal*, to Group Captain E. A. Whitely, for his paper on "The Spacing of Aircraft under High Density Approach Conditions".

Commercial Solvents Award in Antibiotics

Drs. Ibert C. Wells (Syracuse, N.Y.), Edwin E. Hays (Chicago, Ill.), E. A. Doisy (St. Louis, Mo.), and William L. Gaby (Philadelphia, Pa.) have been awarded the 1952 Commercial Solvents Award in Antibiotics for work on antibiotics from *Pseudomonas aeruginosa*. These workers have demonstrated that, in addition to pyocyanine, *Pseudomonas aeruginosa* produces several other antibacterial agents; they have worked out methods of isolation, separation and purification of these agents, defined their physical and chemical properties, proposed structural formulæ for them and, by degradation and synthesis, proved the acceptability of the proposed formulæ. The Commercial Solvents Antibiotics Award was established in 1950 and is administered by the Society of American Bacteriologists. It consists of a gold medal and 1,000 dollars, and is awarded to any person or group of persons working in the western hemisphere who have made an outstanding contribution in the field of antibiotics during the past year.

Links between School and University

Believing that the latter years of a pupil's time at school and the years at a university should be as closely integrated as possible, the Council and Senate of the University of Leeds are building up the closest possible links with schools. Last year, for example, two booklets were prepared describing the courses available in science and technology. These booklets are intended to help careers masters and others to advise school boys and girls in their latter years about university courses that will best qualify them for the careers of their choice. The University has also become aware that it must devote close attention each year to the selection of new students of the right academic standards to keep the size of the University about constant. In the annual report for 1951–52, the vice-chancellor, Sir Charles Morris, suggests that this is most likely to be achieved by making a selection from among the applicants as early as possible. The fact that most candidates still apply to several universities and university colleges is the cause of much wasted effort and of much disappointment; it would appear that joint action by universities and university colleges in this matter is both desirable and necessary. To some extent the problem of selection has been made more difficult by the change from School Certificate and Higher School Certificate examinations to the General Certificate of Education examinations. On the other hand, headmasters and headmistresses are giving most helpful confidential reports, and heads of university departments have been able, to a much larger extent than hitherto, to interview applicants for admission and make a personal assessment of promise and suitability.

Use of Antibiotics in Agriculture

Two pamphlets, Statutory Instruments Nos. 1172 and 1174, 1953 (London: H.M.S.O.; 2*d*. each), have recently been issued by the Ministry of Health in connexion with the use of aureomycin and penicillin; the regulations come into operation on September 1, 1953. Aureomycin, which is intended for parenteral injection, is added to substances coming under control of the Therapeutic Substances Act, 1925 (M.H. 220). At the same time, both penicillin and aureomycin, which by the Penicillin Act, 1947, cannot be used except under the direction of doctors, dentists and veterinary surgeons, are now allowed to be incorporated in pig and poultry food with certain safeguards (M.H. 246). Medical supplies of these substances will not be affected. A recent report by the Agricultural Research Council (A.R.C. Report No. 13) has shown that the addition of these substances to pig food increased the live weight gain from 10 to 14 per cent and improved the efficiency of food conversion by 6–7 per cent without affecting carcass quality.

Nigerian Forest Administration: Annual Report for 1950–51

The annual report for the year 1950–51 of the Nigerian Forest Administration (pp. 64. Lagos: Govt. Printer; London: Crown Agents, 1952; 9*d*. net) provides food for reflexion and some uneasiness. After fifty years of a forest service in the country it is difficult to see that a sound basis of administration from the forestry point of view has been brought into force. The approach to forest conservation, instead of being made to the native chiefs by the administration service, was left to the forest officer, who possessed no administrative jurisdiction in the district except over the forest reserves. Consequently, in the south, where the heavy timber forests exist, the area reserved is said to be inadequate for a growing population. The big timber forests were expected to be a source of revenue to the country and the Forest Department was to obtain this revenue. It seems to have been overlooked that, in the past, the first call on the forests in a tropical and sub-tropical country is the provision of the requirements in small materials of the local agricultural population, and, secondly, or of equal importance, the maintenance of forests on the catchments of rivers and streams. For this purpose the government of the country requires to have at its elbow a senior forest expert who can advise on and guide the general forest policy and see that it is carried out throughout the several parts of the country. From the present report it appears that the Nigerian Forest Department is to be split up into three regional units each with its own chief conservator, the whole being loosely knit under the influence, but not command, of an inspector-general of forests—a most ambiguous expression, so far as his responsibilities are concerned. Africanization of the Department is proceeding apace, and it is difficult to visualize the kind of forest administration and management which the British forest officers will apparently be handing over in due course to their African successors.

Sheffield Organization for the Interchange of Technical Publications

The twentieth annual meeting of the Organization for the Interchange of Technical Publications in Sheffield and District was held recently in the Central Library, Sheffield. The admission of the British Iron and Steel Research Association brought the total membership up to forty, including industrial establishments fifteen miles distant from the city. During the year 1,937 publications were interchanged, this being a record total. The meeting considered the difficulties caused by the lack of current indexes of Patent Office publications and urged the issue of weekly alphabetical name indexes in the official *Journal*, with quarterly and annual cumulations. A complete revision of the union list of periodicals and their files available in the libraries of members was

also recommended. It was reported that the City Science and Commerce Library had been made a deposit library for the reports of the British Atomic Energy Research Establishment; the reports of the United States Atomic Energy Commission are already held in the library. All these reports are available for loan outside the area on payment of postage. The members of the Organization agreed to co-operate in the production and issue of additions to the "Research Bibliographies" prepared by the City Science and Commerce Library, the sixty-first of which, "Shell Moulding Practice (Croning or 'C' Process)", has been in heavy demand from many parts of the world.

Recording Photoelectric Photometer at Kodaikanal Observatory

THERE are certain inherent disadvantages in using photographic photometry in the study of profiles of Fraunhofer lines, and workers in this field have felt the need for a spectrophotometric technique independent of the photographic process. When Brück was at Cambridge some years ago, he devised a photoelectric spectrophotometer using a vacuum photo-cell in conjunction with an electrometer triode; a recording photoelectric spectrophotometer has been built at the Kodaikanal Observatory on essentially similar lines and is described in a paper by A. K. Das, R. Ananthakrishnan and B. N. Bhargava, recently reprinted from the *Indian Journal of Meteorology and Geophysics* (**2**, No. 2; April 1951). The spectrum is provided by a high-dispersion prism spectrograph—a seven-prism instrument with a focal length of about 21 ft., giving a dispersion of 2·4 A. per mm. in the region of the *D* lines. The spectrograph is fed by an 18-in. siderostat through a 12-in. photovisual lens of focal length 21 ft. The upper half of the spectrum is focused on to the photographic plate and is used in the customary way, the lower half being deflected towards the side of the spectrograph camera by means of a right-angled prism. This is adjusted so that the deflected spectrum is also in focus at the scanning slit of the photometer. The light from this slit, which is about 0·03 mm. wide, is received by a short-focus convex lens fixed at a distance from the slit equal to its focal length. The parallel beam of light so obtained from a narrow section of the spectrum is directed again by a second right-angled prism to the photo-cell. The details of the instrument are shown by the three diagrams. Although primarily designed for use in solar line-contour work, its sensitivity can be easily reduced and thus its stability increased. For use in certain visual observations, a less sensitive prototype of the instrument has been constructed. It is suggested that a photometer of the type described could deal with various problems of interest to geophysicists.

Sunspot Observations in Spain

A SUMMARY of the observations made at Madrid Observatory during 1951 is given by E. Gullón in the *Boletín Astronómico Del Observatorio De Madrid* (**4**, No. 5; 1952). As in previous years, the observations were made with the Zeiss spectroscope, mounted in the equatorial Grubb telescope with object glass 20 cm. aperture and focal length 3 m. Six tables are published giving the usual details regarding the observations, and there are many illustrations showing large prominences at various times during the year. These are followed by a number of tables giving details of the observations of sunspots made in 1951 in the observatories of Madrid, Valencia, Cartuja (Granada) and Ebro. All the observations made at the different observatories have been sent each quarter to the International Bureau at Zurich, following the precedent of previous years.

Factory Problems

THE latest publication by the Institute of Personnel Management in its series of Occasional Papers is one by Wilfred Brown. The author is the managing director of the Glacier Metal Co., which, for many years, has been conducting a serious attempt to understand the managerial and social problems of to-day. In 1948 it undertook, with the Tavistock Institute of Human Relations, a joint sociological research into such matters. One of the results of this research has been the emergence of a series of defined ideas and concepts stating the social processes in use in its factories. The paper is an attempt to describe those ideas and concepts upon which its leaders, managers, technicians, shop stewards and representatives are basing their methods of dealing with the day-to-day technical, economic, production and administrative problems encountered in operating the company. The Company is continuing its research activities in this field, and believes that the work so far done is but a start in the long process of achieving a greater degree of scientific objectivity in the social affairs of a factory. The paper, "Some Problems of a Factory", may be obtained from the Institute of Personnel Management, Management House, Hill Street, London, W.1.

Courtaulds' Scientific and Educational Trust Fund: Awards

THE trustees of the Courtaulds' Scientific and Educational Trust Fund have announced the award for 1953 of the following postgraduate research scholarships in a branch of science related to the textile, plastics and allied industries, the awards being worth £400 and tenable for one year at the institute shown: D. W. Bannister, University of Oxford (renewal of 1952 award); C. S. Chadwick, Manchester College of Technology (renewal of 1952 award); P. G. Francis, University of Reading; A. J. Head, Birkbeck College, London; R. M. Hochstrasser, University of Edinburgh; D. Margerison, University of Liverpool; R. I. C. Michie, Manchester College of Technology; Miss E. R. Robertson, University College, Dundee; P. T. Speakman, University of Oxford (renewal of 1952 award); B. D. Stead, University of Birmingham (renewal of 1952 award); R. Stephens, University of Birmingham. Postgraduate research scholarships in textile technology, worth £320 for the first year and £360 for the second year (except where otherwise shown), have been awarded as follows: C. B. Chapman, University of Leeds; G. E. Cusick, Manchester College of Technology; A. F. Greenwood, University of Leeds; D. R. Hardisty, Manchester College of Technology; F. K. Hall, University of Leeds (renewal of 1951 award for one term); H. B. Hallows, Manchester College of Technology (renewal of 1951 award for one year); G. M. Jeffrey, University of Leeds (renewal of 1951 award for one year).

Eighth International Congress of Botany

THE Eighth International Congress of Botany will be held in Paris during July 2–14, 1954, in conjunction with the hundredth anniversary of the

Botanical Society of France. Besides the plenary meetings, the Congress will consist of section meetings which will be divided into two categories: those devoted to organized colloquia on definite topics; and those devoted to sundry communications. For the former, general reports not exceeding twenty thousand letters and original communications not exceeding five thousand letters, and for the latter, summaries not exceeding two thousand letters, may be submitted, and they should all be sent to the respective section secretaries before January 15, 1954. In addition to the Congress events, there will be meetings of a number of Commissions of the International Union of Biological Sciences. The official languages of the Congress will be English and French, but if sufficient advance notice is given, interpreters can be arranged for those who may wish to speak in German, Russian or Spanish. A large number of excursions are being organized, some of which, including those to North and West Africa, will take place before the Congress, and early notice is requested of those who wish to participate. The fee for those taking part in the Congress will be 5,000 francs (about £5 or 15 dollars), with half-rates for students and for those merely accompanying participants. All correspondence on matters not relating to the individual sections should be addressed to the Secrétariat Général, 8e Congrès de Botanique, C.N.A.M., 292 rue Saint-Martin, Paris 3e, from which registration forms, programmes and all further information can be obtained.

The Night Sky in September

New moon occurs on Sept. 8d. 07h. 47m., U.T., and full moon on Sept. 23d. 04h. 15m. The following conjunctions with the moon take place: Sept. 1d. 16h., Jupiter 4° S.; Sept. 5d. 03h., Venus 0·3° N.; Sept. 6d. 17h., Mars 3° N.; Sept. 11d. 22h., Saturn 8° N.; Sept. 29d. 03h., Jupiter 4° S. In addition to these conjunctions with the moon, the following conjunctions of planets with bright stars occur: Sept. 13d. 01h., Mars 0·8° N. of Regulus; Sept. 23d. 09h., Venus 0·4° N. of Regulus; Sept. 29d. 17h., Mercury 1·6° N. of Spica. Mercury, a morning star at the beginning of the month, is in superior conjunction on September 7, afterwards becoming an evening star, but is too close to the sun during the month for favourable observation. Venus, a morning star, rises at 1h. 55m., 2h. 30m. and 3h. 10m. on September 1, 15 and 30, respectively; its stellar magnitude is about − 3·4, and the visible portion of the illuminated disk varies between 0·78 and 0·86. Mars, a morning star, rises about 3h. 30m. during the month and can be seen in the constellation Leo, through which it has an eastward movement; towards the middle of September it lies a little north of Regulus. Jupiter rises at 22h. 45m., 22h. and 21h. on September 1, 15 and 30, respectively, its stellar magnitude being about − 2. During the month it moves eastward from north of ζ Tauri towards the constellation Gemini, and this movement is easily detected. Saturn sets at 20h. 15m. on the first of the month, and an hour after sunset during the middle of the month, after which it draws too close to the sun for favourable observation. Occultations of stars brighter than magnitude 6 are as follows, observations being as if made at Greenwich: Sept. 27d. 2h. 30·9m., 17 Taur. (*D*); Sept. 27d. 3h. 05m., 23 Taur. (*D*); Sept. 27d. 3h. 33·5m., 17 Taur. (*R*); Sept. 27d. 3h. 43·1m., η Taur. (*D*); Sept. 27d. 4h. 15·5m., 23 Taur. (*R*); Sept. 27d. 4h. 37·5m., 27 Taur. *m*. (*D*); Sept. 27d. 4h. 57·6m., η Taur. (*R*); Sept. 28d. 23h. 50·1m., 125 Taur. (*R*); *D* and *R* refer to disappearance and reappearance, respectively. Autumnal equinox takes place on September 23d. 08h.

Announcements

The Institution of Metallurgists announces that the Duke of Edinburgh will open the Platinum Metals Exhibition organized by the Institution at Grosvenor House, London, on October 19. The Exhibition is being held to mark the 150th anniversary of William Hyde Wollaston's announcement of his discovery of palladium, and will be open to the public during October 22–24.

Mr. William E. Miller, editor of the *Wireless World*, has been re-elected president of the British Institution of Radio Engineers for a second term of office. The senior award of the Institution, the Clerk Maxwell Premium, has been awarded for 1952 to Dr. Charles Süsskind, of the Microwave Laboratory, Stanford University, for his paper on "Obstacle-Type Artificial Dielectrics for Microwaves", published in the Institution's *Journal* of January 1952.

A Faraday Society General Discussion on "Dyeing and Tanning" will be held in the Department of Chemistry, University of Leeds, during September 8–10. The Discussion will be divided into two parts, devoted to rate processes and structural effects, respectively, and will be preceded by a general introduction by Sir Eric Rideal. Further information can be obtained from the Secretary, Faraday Society, 6 Gray's Inn Square, Gray's Inn, London, W.C.1.

The British Society of Rheology is arranging a symposium on "The Mixing of Thick Liquids, Pastes and Slurries", to be held in the Main Chemistry Lecture Theatre of the Imperial College of Science and Technology, London, on September 25. The symposium will be preceded by the annual general meeting of the Society. Admission to the symposium is free, without ticket. Further information can be obtained from the Honorary Secretary, British Rheological Society, Flat H 12, Sloane Avenue Mansions, London, S.W.3.

The eleventh annual meeting of the Electron Microscope Society of America will be held at the Pocono Manor Inn, Pocono Manor, Pennsylvania, during November 5–7. Programmes with abstracts of papers to be presented will be available after October 15 from the programme chairman, A. R. T. Denues, Sloan-Kettering Institute for Cancer Research, 444 East 68th Street, New York 21, N.Y. Local arrangements are being made by Kenneth S. McCarty, Veterans Administration Hospital, 130 West Kingsbridge Road, Bronx, New York.

In the article entitled "International Electro-Acoustics Congress" in *Nature* of August 1, p. 189, it is stated that the International Committee of Acoustics is "an offshoot of Unesco". This is not correct. The Committee belongs to the International Union of Pure and Applied Physics, and it received a subvention this year from Unesco through that Union and the International Council of Scientific Unions.

Erratum. In the communication entitled "Biogenesis of Alkaloids of Solanaceæ" by Sir Robert Robinson in *Nature* of August 22, p. 344, penultimate paragraph, for "this base" read "cuskhygrine".

IMPURITY PHENOMENA IN PHYSICS AND CHEMISTRY

A THREE-DAY symposium on "Impurity Phenomena" was held at the Knoll's Research Laboratory of the General Electric Co., Schenectady, during June 16–18, arranged by the Division of Physical and Inorganic Chemistry and the Eastern New York Section of the American Chemical Society in conjunction with the Division of Solid State Physics of the American Physical Society. About three hundred persons attended the symposium, and it proved a very successful meeting-ground for chemists and physicists active in a field in which contributions of both groups have been significant.

The first session, under the chairmanship of Dr. F. E. Williams (General Electric Research Laboratory), dealt with general aspects of impurity phenomena. Prof. F. Seitz (University of Illinois) set the stage for the symposium by reviewing the range of crystal imperfections. From such a point of view, imperfections in a perfect crystal include lattice vibrations or phonons; free electrons and holes; excitons (a neutral electron–hole combination); vacancies at lattice sites and interstitial ions or atoms in the lattice; *F*-centres; foreign or impurity atoms or ions; and dislocations. Light interacting with such a crystal is treated in terms of photon impurities in the lattice. Prof. Seitz went on to say that the significant advance of recent years has been in the disentangling of these separate imperfections and in showing their inter-relationships. Thus *F*-centre formation can be shown to be a result of the interaction of several imperfections—dislocations associating to form ion vacancies, free electrons being produced and then being trapped at the negative ion vacancies. The following paper, by Prof. C. Wagner (Massachusetts Institute of Technology), dealt with the role of lattice defects for solubility problems in ionic crystals and stressed the similarities with solubility problems of ideal and non-ideal aqueous solutions. Among the problems cited was the decrease in the solubility of silver sulphide in zinc sulphide in the presence of cuprous sulphide. In general, the solubility of a solute 2 in the solvent crystal 1 will be decreased by presence of a solute 3 if both solutes have either a greater or a smaller cation/anion ratio than the solvent, and thus dissolution of solutes 2 and 3 results in the formation of the same type of defect, either interstitial ions or vacancies. The last paper of the general session was entitled "Evidences of Crystalline Imperfections in Nuclear Magnetism" and was presented by Prof. R. V. Pound (Harvard University). Nuclear paramagnetic resonance has become a tool for the study of the solid state, and some effects were described. The relaxation times measured can indicate the strength of the heat contacts between the spin system and the lattice, and these are modified in the presence of impurities. Paramagnetism associated with lattice constituents was discussed, and the presence of dislocations and their density may also be investigated for 'perfect' and 'work-hardened' crystals.

The second session, under the chairmanship of Dr. P. Pringsheim (Argonne National Laboratory), dealt with the coloration of solids by impurities. Dr. J. H. Schulman (Naval Research Laboratory) indicated how impurities can influence markedly the colorations produced by ionizing radiations on solids. The impurities may change the number of crystal defects due to mis-match in ion size or polarization properties. They may change the concentrations of negative and positive ion vacancies due to electrostatic charge differences between the impurities and host crystal constituents, and they may act as traps for electrons and holes. Since the concentrations required for such effects may be very small, there is a field of investigation unfolding to disentangle the effects mentioned from those associated with host crystals of ultra-purity. Prof. W. A. Weyl (Pennsylvania State College) read a paper on metals in the atomic state in glasses, contrasting with their behaviour in solids. The coloration of alkali halides by the presence of colloidal metal was described by A. B. Scott, W. A. Smith and M. A. Thompson (Oregon State College). Alkali halides containing excess alkali metal, on moderate heating, develop absorption bands due to colloidal metal of estimated particle size 10–50 A. After extended heat treatment, the particle size becomes increased, and scattering of the light then occurs. J. J. Markham (Johns Hopkins University) closed the session with a synthesis of some of the properties of colour centres. He discussed the interaction of colour centres with their environment and separated two classes of interactions—the macroscopic, which affect the rates at which bands are formed during irradiation and affect the bleaching rates both in the light and in dark, and the microscopic, which affect the shape of the band and the bleaching properties at very low temperatures. The question of whether there exists more than one type of *F*-centre depending on the method of preparation still remains open.

The third session, with Dr. H. W. Leverenz (R.C.A. Laboratories) as chairman, dealt with activators in luminescent crystals. Prof. R. Ward (University of Connecticut) spoke on the chemistry of phosphors and on the increasing necessity for ultra-high purity in the preparation of the chemicals. He discussed certain luminescent systems such as zinc sulphide/copper in which the concentration of copper impurity markedly affects the colour of the luminescence. The need for inclusion of compensating ions to satisfy electrical neutrality was emphasized, and he ended with a discussion of recent work on the luminescence of materials with perovskite structure. Dr. C. C. Klick (Naval Research Laboratory) spoke on emission and absorption associated with luminescent centres at low temperatures. The main features at low temperatures are: that the bands remain broad; the emission and absorption band-widths vary as the square root of the temperature at high temperature but vary at a lesser rate and approach a constant value at low temperatures; and some systems show an emission composed of equally spaced 'lines'. Certain of these features could be explained by treating the luminescent centre as a one-dimensional harmonic oscillator. Vibrational frequencies in the range 10^{12}–10^{13} c./s. are obtained on the basis of such a model. Dr. D. L. Dexter (University of Rochester) spoke on the theory of sensitized luminescence in solids. To obtain sensitized luminescence one adds to the host crystal two sets of activators. One, the sensitizer, possesses strongly allowed optical transitions and absorbs the incident radiation, the other, the activator, has a forbidden transition; and the two are chosen so that

the emission band of the sensitizer overlaps the absorption band of the activator. There is then a radiationless transfer of energy from the sensitizer to the activator. The extent of the sensitized region surrounding each sensitizing centre was indicated as about thirty lattice sites with a general increase in sensitivity in the region of a thousand. The theory of the luminescence of impurity-activated ionic crystals was discussed by Dr. F. E. Williams (General Electric Research Laboratory), who indicated how refinements to the recent theory of the luminescence of thallium-activated potassium chloride improve agreement between theory and experiment. The angular dependence of the wave function of the excited state affects the luminescence peak-shape. An evaluation of the first-order perturbation of the energies of the activation ions by the crystal field indicates that it is appreciably different for the ground and excited states, thus altering the position of the emission and absorption peaks. Dr. R. H. Bube (R.C.A. Laboratories) gave a general paper on traps and trapping processes and their importance for luminescence theory, particularly in affecting frequence response. Traps due to host crystal imperfections and due to the presence of impurities have been separated and studied for sulphide and silicate phosphors.

The next session was devoted to the photographic process. In his introduction, the chairman, Dr. J. A. Leermachers (Kodak Research Laboratories) indicated the scope of the photographic process, its dependence on rate processes and the problems connected with the primitive sensitivity and the superimposed chemical effects. Dr. F. Urbach (Kodak Research Laboratories) presented a paper, read by Mr. D. Pearlman, on some effects of inorganic impurities on silver halide crystals. Slight traces of alkaline earth metals in silver bromide produce luminescence at 77° K. with long afterglow. In addition, very slight amounts of nickel and gold in silver bromide have been found to produce marked effects. Dr. G. W. Luckey (Kodak Research Laboratories) discussed recent measurements performed on the vacuum photolysis of silver bromide. The pressure of photolytic bromine was measured for slabs, crystals and evaporated films and the quantum yield—that is, the number of bromine atoms produced per quantum of light absorbed—was found to increase with decreasing wave-length. The results showed vacuum to be a good halogen acceptor, and the quantum yield is near unity when the concentration of electron traps is high. For thick specimens the decomposition that produced measurable quantities of bromine occurred in a surface layer of the crystals of thickness approximately 0·3 micron. Dr. W. West (Kodak Research Laboratories) read a paper on the effect of impurities on the optical sensitization of the photographic emulsion. It is well known that the general level of sensitivity of silver halide photographic emulsions may be increased by the presence of chemical impurities on the surface, as for example sulphur, which may be introduced during the emulsion-ripening process. There are also other sensitizers—for example, certain dyes—which confer sensitivity in the long wave-length region and the general level of activity of which is governed by the presence of slight traces of additional impurities which may increase sensitivity (super-sensitizers) or decrease sensitivity (anti-sensitizers). A general mechanism associated with these processes was presented. The session closed with a paper by F. W. H. Mueller, H. Hoerlin and E. T. Larson (Ansco Division) describing the sensitization of X-ray emulsions by very small quantities of a divalent salt such as lead or cadmium bromide.

"Analysis for Trace Impurities" was the subject of the fifth session under the chairmanship of Prof. W. D. Cooke (Cornell University). Dr. M. G. Inghram (University of Chicago) outlined the use of the mass spectrometer for trace element determination with particular emphasis on the isotopic dilution method. Analysis for trace impurities by neutron activation was described by W. A. Brooksbank, G. W. Leddicote and H. A. Mahlman (Oak Ridge National Laboratory), and the sensitivity of the method in several instances was cited. Details were described of the recently inaugurated public service whereby specimens may be submitted for analysis at the Oak Ridge National Laboratory. A second paper, by W. A. Brooksbank and G. W. Leddicote, described procedures for separating out trace impurities by ion-exchange methods for use in conjunction with the neutron-activation techniques. The combination provides an extremely sensitive and specific method for the determination of small quantities of the rare earths and alkali elements in the presence of each other. Dr. L. Strock (Sylvania) followed with a paper on the extension of the sensitivity of emission spectroscopy both by physical means within the light source and by means external to the source. The methods have been used for impurity estimation in germanium in the 10^{-5} to 10^{-7} weight per cent range—that is, 1 part impurity in 10^{9}–10^{9} atoms. C. A. Streuli and W. D. Cooke (Cornell University) discussed the application of a polarized mercury-pool electrode to polarography, indicating its advantages coupled with greater sensitivity compared with the dropping-mercury electrode. Polarograms for several metals were shown with a sensitivity of about 20×10^{-9} gm./ml.

The final session, under the chairmanship of Dr. A. H. White (Bell Telephone Laboratories), was devoted to papers discussing the role of impurities in semi-conductors and transistors. The equilibrium thermochemistry of solid and liquid alloys of germanium and silicon was discussed by C. D. Thurmond and J. D. Struthers (Bell Telephone Laboratories). The solubilities of antimony and copper in germanium were determined. Dr. R. N. Hall (General Electric Research Laboratory) discussed the segregation of impurities during the growth of germanium and silicon crystals. By a radiographic technique this segregation was observed and its dependence on rate-growth and crystal orientation determined. Since this dependence is generally much greater for donor impurities than it is for acceptors, it makes possible the growth of crystals containing large numbers of p-n junctions. H. M. James and A. S. Ginsberg (Purdue University) read a theoretical paper on the effects of impurity atoms on the band structure of alloys and semi-conductors on the basis of a one-dimensional alloy or crystal. The sharply defined impurity band for a crystal with the regularly placed impurities becomes replaced by a broadened region of high energy-level density when the impurities are randomly arranged. E. Burstein, E. E. Bell and J. W. Davisson (Naval Research Laboratory) and M. Lax (Syracuse University) discussed some optical investigations of impurity-levels in silicon at the temperature of liquid helium. Optical absorption by neutral impurities may involve two things: photo-ionization of bound-charge carriers, which is accompanied by photo-conductivity; and optical excitation of bound-charge

carriers from the ground-state to higher energy-states which appears as relatively narrow bands at wavelengths beyond the photo-ionization limit. Such transitions are observed in boron-doped specimens at 28·7, 31·2 and 36·0 microns, which are attributed to $1s$–$4p$, $1s$–$3p$ and $1s$–$2p$ transitions respectively. J. A. Burton, G. W. Hull, F. J. Morin and J. C. Severiens (Bell Telephone Laboratories) described the effects of nickel and copper impurities on increasing the rate of recombination of holes and electrons in germanium. The dependence of lifetime on resistivity at room temperature is consistent with the Shockley–Read–Hall theory of recombination at traps near the middle of the forbidden band. The capture cross-section of these traps for holes and electrons were estimated. The final paper, by Dr. S. R. Morrison (University of Illinois), described measurements on the changes of surface conductivity of germanium with ambient atmosphere, in which the changes of conductivity were correlated with changes in the space charge layer at the free surface of the semi-conductor.

The majority of the papers read at the meeting will be published in the November issue of the *Journal of Physical Chemistry*. W. GRATTIDGE

INSTITUTE FOR THE ENCOURAGEMENT OF SCIENTIFIC RESEARCH AND AGRICULTURE, BRUSSELS

REPORT FOR 1952

THE annual report for 1952 of the Institute for the Encouragement of Scientific Research and Agriculture, Brussels*, records forty-one grants made during the year, totalling 99,894,670 Belgian francs. Of this sum, 16,870,000 francs went to the Committee for Mapping the Soil and Vegetation of Belgium for systematic studies of the pedological character of the soils and completing the pedological map. A grant of 8·19 million francs went to the Committee for the Study of the Disease and Nutrition of Cattle, partly for research on trichosomiasis and brucellosis and partly for investigations on nutrition. The National Centre for Grass and Fodder Research received 7·35 million francs for research on the rational and intensive exploitation of grass in Belgium, and the National Centre for Metallurgical Research 7·18 million francs in support of its programme of research on the determination of gas and the influence of the presence of gas in metals, the determination of occlusions in steel, spectral analysis and metallurgical physics. These investigations have included comparative studies on the determination of nitrogen in ferrous alloys, cast iron and special steels, the deoxidizing action of silicon, aluminium, silico-aluminium, silico-calcium and magnesium, and micro-kinematographic studies of fracture by bending. The National Committee for the Study of Fruit Culture received a grant of 5,632,250 francs in support of a programme of work bearing on the rational development of orchards, for researches relating to soils and manures, plant investigations, including systematic studies on plums and apples, cytological research, and researches on fruit pathology. A grant of 4·45 million francs went to the Committee for the Scientific and Technical Study of Milk and its Products for work in this field, including the preservation of milk, the changes occurring in butter on storage in refrigerators, the microbial floral and chemical composition of different makes of cheese, and studies on the preparation of acidified milks such as yoghourt. 3·81 million francs to the Technical and Scientific Centre of the Belgian Glass Industry were for the continuation of investigations on the annealing of glass, on the physical and chemical properties of different glasses and on the manufacture of mirrors.

The Centre for Studies and Research into Hydroponics received 2,525,000 francs for its investigations on the behaviour of certain agricultural and horticultural plants on cultivation in mineral substrata and on the mineral nutrition of vegetables; 2,312,500 francs went to the Belgian Centre for the Study and Documentation of Water for research on water treatment, on rust and corrosion and on effluents; and 2,276,500 francs to the Committee for the Study of Metallic Creep at Ordinary Temperatures for further work on creep in hardened steel. The Centre for the Study of High Polymers received 2,262,000 francs for chemical and physico-chemical investigations on high polymers, and the Committee for the Study of Metallic Creep at High Temperatures 2,088,000 francs for investigations on the creep of steel above 575° C.; 2,040,000 francs were granted to the Committee for the Study of Organic Matter in Belgian Soils for investigations on the degradation of certain soils through loss of structure, and 1,892,000 francs for investigations into animal and vegetable physiology using the radioactive isotope technique. Research on the machinability of steel received a grant of 1,849,000 francs; 1,781,300 francs went to the Centre for Scientific and Technical Research of the Metal Industry for casting research; 1·7 million francs for pathological and genetical research on the potato; 1,460,000 francs for corrosion research, including cathodic protection and the study of descaling treatments; 1·24 million francs to the Tobacco Commission of the Provincial Agricultural Committee of Western Flanders for research on the commercial cultivation of tobacco; 1·13 million francs for research on the cultivation, conservation and utilization of medicinal and aromatic plants; and 1·12 million francs to the Committee for Research into Cereal Diseases.

Among smaller grants may be noted those for cotton research (922,500 francs), for investigations on the culture of mushrooms (770,000 francs), for research on the sensitization and granulation of photographic emulsions (700,000 francs), for scientific and technical research at high pressures (595,000 francs), for welding research (531,000 francs), for investigations on the specific heat of organic compounds (360,000 francs), for microbiological investigations on vinegar manufacture (111,250 francs) and 270,000 francs for investigations on the cultivation of maize in Belgium. The Belgian Centre for Naval Research received 450,000 francs in support of research on thermal and acoustic insulation, while 722,000 francs were granted to the Research Centre of the Belgian Ceramic Industry for investigations on the plasticity of pastes and viscosity of slips used in ceramics and 712,500 francs to the Technical Centre of the Textile Industry for investigations on the oiling of jute fibres. A list of publications relating to assisted researches appearing during the year is included.

* Institut pour l'Encouragement de la Recherche Scientifique dans l'Industrie et l'Agriculture. Rapport Annuel, Exercice 1952. Pp. 175. (Brussels, 1953.)

DEPARTMENTS OF TEXTILE INDUSTRIES AND COLOUR CHEMISTRY AND DYEING, UNIVERSITY OF LEEDS

REPORTS FOR 1950–52

THE Advisory Committee on the Departments of Textile Industries and Colour Chemistry and Dyeing of the University of Leeds has made two reports, for the sessions 1950–51 and 1951–52, respectively, to the Worshipful Company of Clothworkers of the City of London*. That for the session 1950–51 refers to continued excessive pressure on accommodation. In the Department of Textile Industries, where students will in future be able to read for honours degrees in textile physics, textile chemistry or textile engineering, the equipment of all sections is now in excellent condition, permitting both teaching and research on the most modern machinery. In the textile physics section the electron microscope has been used for examining keratin and also the disintegration of cellulose fibres in strong mineral acids. A further laboratory has been equipped for teaching and routine work on the examination of fibres by the microscope and other optical methods, and in the weaving section progress is reported in studies of cloth-setting and the influence of structural differences, in respect of yarn, weave interlacing and sett, on the properties of woven fabrics. In the finishing section, besides work on the action of metal amines on proteins, the properties of viscose rayon containing vinyl polymers have been examined with the object of developing methods for producing dimensionally stable rayon fabrics. Work in the textile chemistry section has dealt with the behaviour of the alcohols and esters of wool wax at the air–water interface, variation in sulphur content and plasticity among wool fibres, the swelling of keratin, the dissolution of wool and the action of neutral salts on animal fibres. In the Department of Colour Chemistry and Dyeing, progress is reported in the study of the self-union of organic compounds such as mesobenzanthrones and pyrazoleanthrones, a satisfactory explanation of the mechanism of formation of flavanthrone in the alkali fusion of 2-aminoanthraquinone has been obtained, and an investigation of the substitution of cinnoline, phthalazine, quinoxaline and quinazoline by anions was commenced. Lists of publications are included.

The report for the session 1951–52 reports a record number of students in the Department of Textile Industries and a further increase in students in the Department of Colour Chemistry and Dyeing, where two new scholarships for research in colour chemistry have been endowed, as well as two new studentships. In the textile physics section an ultrasonic technique was being applied to both keratin and cellulose, and a new type of rotating vacuum seal being developed for use in interpreting the molecular structure of keratin. In the textile chemistry section conclusive proof has been obtained that the variation in plasticity among the fibres in a single staple is associated with the age of the follicles from which they are derived, and the formation of cross-linked polymers inside wool fibres by co-polymerization of compounds such as divinyl ether and methacrylic acid has been studied, while methods were being devised for weighting the different types of side-chains with heavy metal atoms so that their distribution could be determined by X-ray examination of the treated fibre. Two quantitative methods of estimating the amount of medulla in hairy wools have been discovered, and in textile engineering the performance of the prototype electronic mule has been so satisfactory that the first large-scale model was being built for trial in a Yorkshire mill. The action of metal amines on wool and other proteins and the influence of various treatments on the dyeing properties of wool was being examined in the textile technology section in co-operation with the Department of Colour Chemistry and Dyeing. Other problems being investigated included the bleaching of pigmented fibres, the setting of nylon, and the assessment of damage in textile materials.

In the Department of Colour Chemistry and Dyeing work on the constitution of the anthraquinone–carbazole dyes and the mechanism of their formation points to the possibility of a general theory of reactions involving condensation of organic compounds by hydrogenation. A study of the condensation of amines with aromatic nitro-compounds was commenced, and an investigation of the reduction of anthraquinone derivatives with alkaline sodium dithionite, which indicates an unexpectedly frequent formation of anthrones, has a direct bearing on the application of vat dyes. Work on the preparation and orientation of the *tert.*-butyl derivatives of acenaphthene was completed, and that continued on the resolution of *dl*-mandelic acid and its derivatives into optically active forms on wool and on the chemical and physical factors concerned in the application of dispersed dyes to cellulose acetate rayon.

* University of Leeds. Report to the Worshipful Company of Clothworkers of the City of London of the Advisory Committee on Departments of Textile Industries and Colour Chemistry and Dyeing during the Session 1950–51. Pp. 41. Report for the Session 1951–52. Pp. 38. (University of Leeds, 1951–52.)

A NATURALIST IN SOUTHERN ETHIOPIA

DR. HUGH SCOTT, who has just returned from yet another journey to Abyssinia, has placed in his debt everyone whose scientific interests include this remarkable part of the world. On his expedition of 1948–49, which is dealt with in a recent paper*, as on his first, Dr. Scott's main purpose was to collect insects at high altitudes; but incidentally he acquired a great deal of information about the country and its inhabitants. Much of the area he passed through was little known and it was exceedingly ill-documented, especially in English; therefore the account that he gives of the topography, vegetation and climate provides, in addition to an account of a naturalist's journey, as fascinating in itself as his account of the Yemen ("In the High Yemen." 2nd edit., 1949), an invaluable background to any biological work concerned with the area traversed. The text is supported by a good bibliography, and a special feature of the paper is the twenty-six plates, illustrating a variety of subjects of interest to the botanist, ethnologist and geographer.

* Journey to the Gughé Highlands (Southern Ethiopia), 1948–49; Biogeographical Research at High Altitudes. By Dr. Hugh Scott. *Proc. Linn. Soc.*, Session 163, 1950–53. Pp. 85–189 + 26 plates.

Dr. Scott reached Addis Ababa on August 20, 1948; but the unusually heavy rains had done so much damage to the roads he wished to traverse that he was not able to start until October 15. He returned to the capital on January 28, 1949, after a remarkable journey, with no European companion, which took him to within about seventy miles of the Kenya border. His main objective was the high ground west of the Rift Valley, Mt. Damota (10,400 ft.) and the almost legendary Gughé Highlands, rising to 13,780 ft. He continued south through Konso to Yavello and returned to his base up the eastern side of the Rift. It is pleasant to record that on his 1948–49 journey Dr. Scott found public security much better than it had been when he was travelling in the country during 1926–27.

The account of the journey is prefaced by a section on "Biogeographical Considerations", in which Dr. Scott briefly considers the "zones of vegetation in southern Ethiopia" (with special reference to those on the mountains he personally explored) in relation to published information about the biology of mountain country elsewhere in Africa. In this connexion he discusses certain groups of Coleoptera in which he is a specialist; and also the effects of isolation on the evolution of congeneric species, together with the parallel evolution of certain insects along with the high-mountain plants with which they are so closely associated.

Although his main task in Ethiopia was the collection of observations on and specimens of insects, Dr. Hugh Scott made a most useful botanical collection. Hitherto, nothing much was known of the vegetation of Mt. Damota and the Gughé Highlands, and no collections of plants from these mountains had ever been made. Dr. Scott is to be congratulated on bringing home many plant specimens in such an excellent state of preservation that one might have imagined that they had been taken and prepared under ideal conditions. This, however, is far from the truth, for much of the time that he was at high altitudes, Dr. Scott was working under very austere and unpleasant conditions. The Gughé Highlands in particular are notoriously wet. That Dr. Scott endured "raw, damp weather, with thunder on two nights" when camping at about 10,600 ft. on Mt. Tola, is certainly not reflected in the specimens he obtained.

Botanically the chief interest in the collection is that it comes from an area situated between the Simien Highlands, so well collected by German and French collectors in the first half of the past century, and the highlands of Kenya, the flora of which is now comparatively well known. When Dr. Scott's plant collections are finally worked out, the preliminary determinations of which are listed at the end of his paper, many gaps in our knowledge of the distribution of plants on the mountains of Africa will have been filled.

About half the paper is taken up with the "Description of the Country, with Natural History Notes", to which are added three appendixes. The most important of these deals with the author's archæological and ethnological observations, with special reference to the phallic monoliths of Walāmo and Sidāmo. These exist in thousands, many of them up to ten feet in height, yet they are very little known. In his main narrative Dr. Scott gives full rein to his very wide natural history and human interests. They range from the Addis Ababa gardens, and the butterflies and birds that frequent them, to the spread of prickly pear, the practices of the local bee-keepers and the uses made of the local bamboos. He found almost everywhere that extensive inroads had been made into the native vegetation, and that in places cultivation had been carried right up to 10,000 ft. Yet in parts of the south, splendid primary forests still exist. He gives, of course, special importance in his narrative to the mountain massifs that were his principal objective; and anyone who has had the good fortune to be a pioneer in any branch of biological exploration in an unknown locality will live again with him the enthusiasm with which he toiled up those distant slopes.

R. E. Moreau
E. Milne-Redhead

GRAZING BEHAVIOUR OF BULLOCKS

Environmental factors which can influence the behaviour of a herd of bullocks may be divided into, first, the natural conditions of climate, including seasonal changes and weather; and secondly, the system of management of the bullocks.

Methods of management, the ways in which grass, in different quantities and of varying quality and palatability, is offered to the beasts, fall into two categories. The grazing may be uninterrupted from day to day, as in free-range and rotational systems. Other methods exercise some form of daily control over the quantity of herbage allowed the bullocks, which may be a control of area or of time allowed on the grass. In a recent article, J. C. Tayler, of the Grassland Research Station, Stratford-on-Avon, has described the behaviour of Hereford-cross bullocks under two management systems in these categories (*Brit. J. Animal Behaviour*, **1**, No. 2; April 1953).

These studies have shown that the grazing behaviour of bullocks in a herd may be regarded as following a repeated daily pattern closely related to environmental factors. Of these factors, the varying hours of daylight throughout the year produce seasonal changes in the basic pattern. Weather and other disturbances may affect the grazing pattern in many minor ways; but, next to seasonal effects, those resulting from the system of management seem to be the most important.

Under the two systems of management, 'rotational' and 'strip' grazing, changes in behaviour resulting from the system may be due to the herbage, through its physical, internal effect as, for example, in winter grazing on limited areas. They may also be due to a daily disturbance as was shown in the 'strip folding' system. Under this system of management the animals show definite signs of appreciating that a fresh supply of grass will be offered later in the morning and delay their main grazing period up to six hours later than it would occur under undisturbed conditions.

Studies of behaviour during the past three years have been used at the Grassland Research Station for improving the accuracy of results in live-weight-increase experiments where bullocks are weighed straight from pasture. A knowledge of their behaviour pattern makes it possible to remove the bullocks from pasture for weighing when the 'fill' of grass in the rumen is approximately the same at each weighing.

HÆMOGLOBIN IN FUNGI

Occurrence of Hæmoglobin in Yeast and the supposed Stabilization of the Oxygenated Cytochrome Oxidase

AT an early stage of the work on the components of cytochrome[1], special experiments were devised for the study of the absorption spectra of these pigments in the presence of hæmoglobin or myoglobin. This was found necessary for the proper understanding of the absorption spectra of cells and tissues where these pigments may co-exist.

Spectroscopic study of yeast cells in presence of added exogenous hæmoglobin. For this purpose a few drops of dilute laked blood or hæmoglobin are added to a suspension of baker's yeast and the mixture is examined in the usual way with a low-dispersion microspectroscope, or hand spectroscope. The amount of blood added should give a concentration at which the distinct bands of oxyhæmoglobin are replaced, on deoxygenation, by the diffuse and faint band of hæmoglobin. Sharp absorption bands are shown by cytochrome only in the reduced state, and by hæmoglobin only in the oxygenated state. Thus, when air is passed through such a mixture the four bands of the reduced cytochrome disappear and are replaced by the two bands of oxyhæmoglobin. When aeration is interrupted and the oxygen of the suspension is used up in the respiration of the yeast, the sharp absorption bands of reduced cytochrome reappear while the two distinct bands of oxyhæmoglobin are replaced by the faint band of hæmoglobin which does not mask the absorption bands of cytochrome.

On the addition of cyanide to an aerated yeast suspension containing hæmoglobin, the bands of reduced cytochrome can be seen side-by-side with those of oxyhæmoglobin. Cyanide, by inhibiting the reoxidation of the reduced components of cytochrome, prevents the utilization of oxygen in yeast respiration and thus protects oxyhæmoglobin from deoxygenation. Under these conditions the α-band of oxyhæmoglobin, which lies at about 577 mμ between bands *a* and *b* of cytochrome, appears as a narrow but distinct band, whereas the β-band, which lies at about 542 mμ, is seen as a diffuse absorption between cytochrome bands *c* and *d*.

For the same reason the addition of cyanide enables the absorption bands of oxymyoglobin to be seen together with the bands of reduced cytochrome in a slice of perfused pigeon-breast muscle, which normally, owing to its high respiratory activity and the difficulty in arranging efficient aeration, has its myoglobin in the deoxygenated state and therefore not easily recognizable. The difficulty in the aeration of such a compact tissue can be temporarily overcome by the addition of a little hydrogen peroxide which, being decomposed by catalase in the muscle tissue, liberates within the slice a sufficient quantity of molecular oxygen for the oxidation of cytochrome and oxygenation of myoglobin[1].

It was the failure on the part of MacMunn to recognize the presence of hæmoglobin (myoglobin) in the perfused pigeon's breast muscle and his wrong assumption that myohæmatin is the sole colouring matter of this tissue that gave rise to the polemical discussion between him and Hoppe-Seyler. This unfortunate discussion was ultimately responsible for the complete disappearance of myo- or histohæmatin from scientific literature and for the delay of more than forty years in the recognition of the fundamental importance of hæmatin compounds in the catalysis of intracellular respiration[1].

The spectroscopic study of yeast in presence of added or exogenous hæmoglobin summarized above will be referred to later in the interpretation of absorption bands which, in addition to those of cytochrome, may occur in cells of certain micro-organisms.

The absorption band at 583 mμ and Warburg's theory of stabilization of an oxygenated 'respiratory ferment' or cytochrome oxidase. To Warburg and Haas[2] we owe an interesting observation that a thick suspension of baker's yeast, deprived so far as possible of metabolites and saturated with oxygen, reveals the presence of a weak but sharp absorption band in the yellow region of the spectrum at about 583 mμ. As soon as the current of oxygen is interrupted, this band disappears and is replaced by those of the reduced components of cytochrome. However, if cyanide is added to the yeast suspension saturated with oxygen, the band at 583 mμ persists and can be seen at its full strength side by side with the bands of reduced cytochrome. In the presence of carbon monoxide the band in the yellow region disappears and, according to Warburg and Haas[2], is replaced by a diffuse band lying between 590 and 600 mμ, where it can be detected photoelectrically.

As to the nature of the compound responsible for the band at 583 mμ, Warburg[3] put forward the view that it is the oxygenated ferrous complex of the 'respiratory ferment'. This view, according to him, is supported by their findings (1) that this band lies within the region of the spectrum where the α-band of the 'respiratory ferment' should be present, (2) that the 'reduction' of this oxygenated complex like that of the oxidized 'respiratory ferment' is prevented by cyanide, and (3) that in the presence of carbon monoxide the band at 583 mμ appears to be shifted towards the red end of the spectrum into the region (590–600 mμ) occupied by the α-band of the photochemical absorption spectrum obtained by Kubowitz and Haas[4] for the carbon monoxide compound of the 'respiratory ferment' of *Torula utilis* and *Acetobacter pasteurianum*. This study led Warburg[3] to the conclusion that the primary reaction in aerobic or 'oxygen respiration' is the formation of the addition product between oxygen and the ferrous atom of the 'respiratory ferment' and that the oxygenated ferrous 'respiratory ferment' varies in the degree of its stability in different cells. In yeast cells he concludes that it is comparatively stable and therefore susceptible to direct spectroscopic observation (band at 583 mμ), whereas in *Acetobacter* the oxygenated ferrous complex is not visible because the iron within this complex rapidly oxidizes to the trivalent state.

The observations summarized above and Warburg's far-reaching conclusions attracted the attention of several workers who have discussed them in their papers, reviews and books. Thus Shibata and Tamiya and their co-workers[5–8], in agreement with Warburg's view, postulated that the first reaction of the ferrous 'respiratory ferment' consists in the formation of an addition complex with molecular oxygen. However, whereas according to Warburg the divalent iron within this oxygenated complex undergoes a more or less rapid oxidation to the trivalent state, according to the Japanese workers the iron, as in oxyhæmoglobin, always remains divalent, and the oxygen

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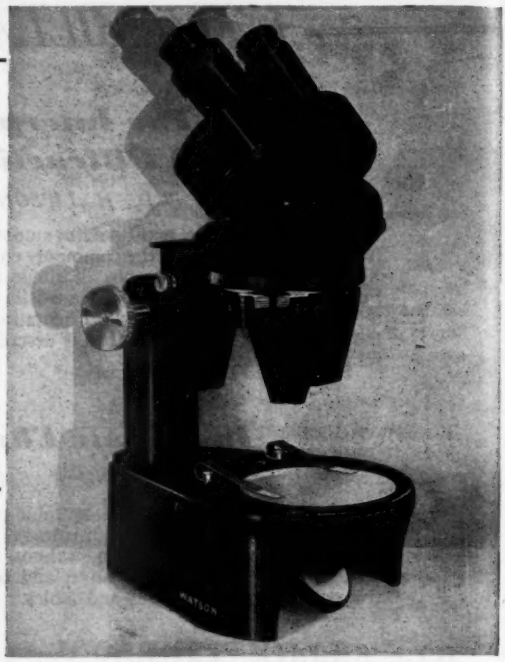

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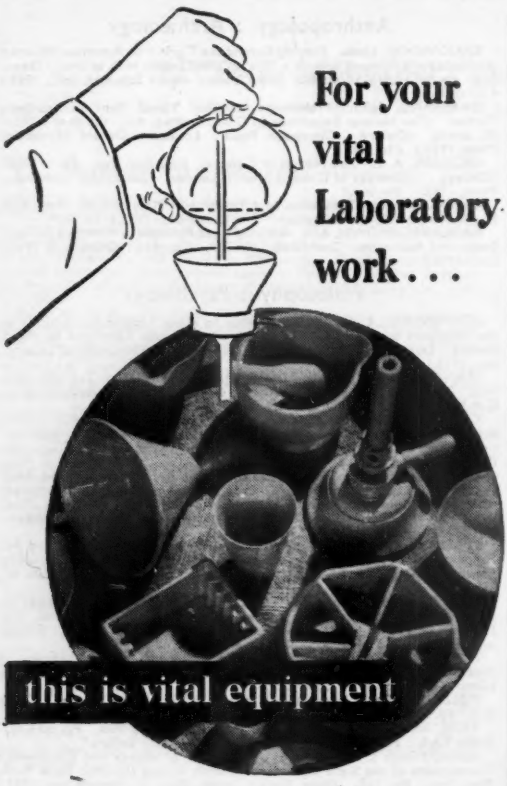

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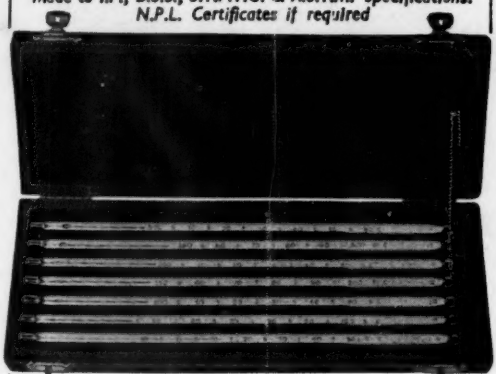

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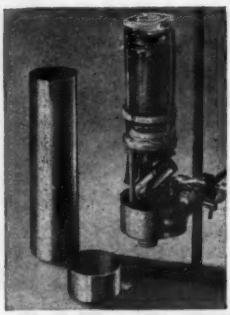

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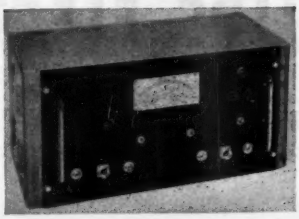

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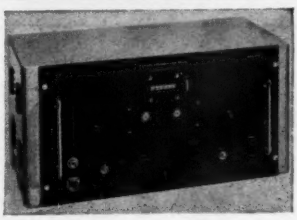

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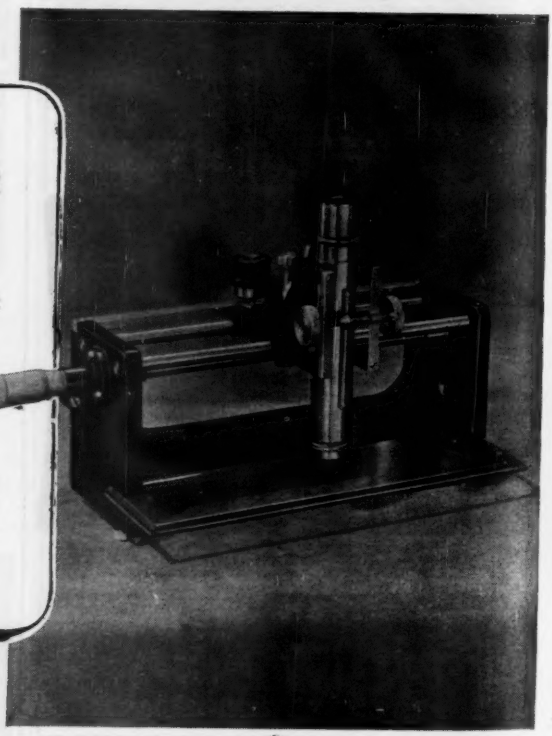

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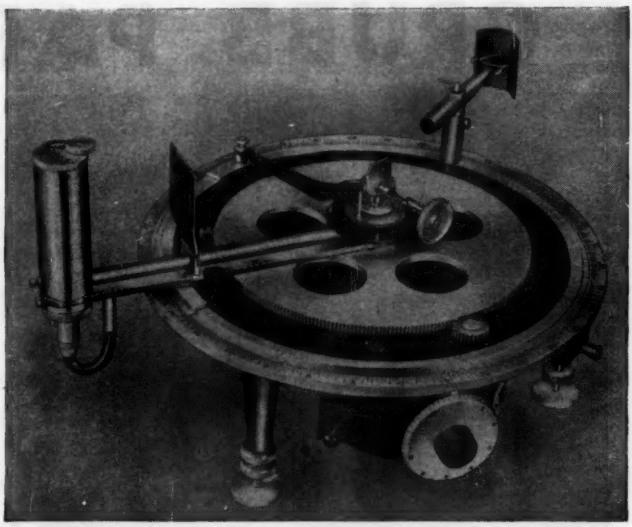

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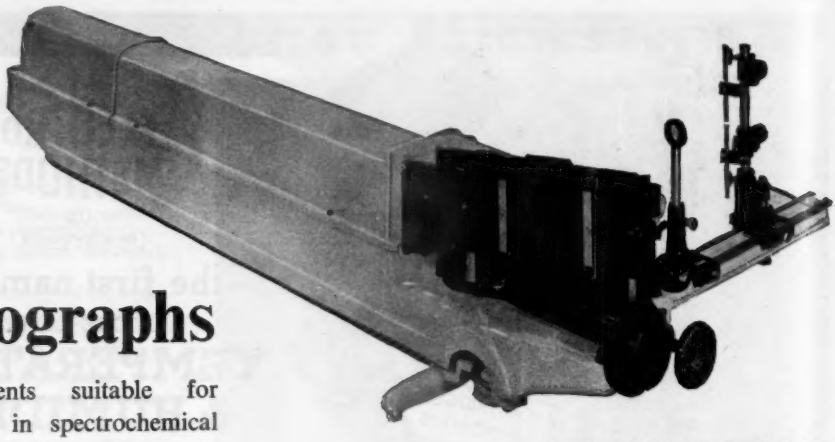

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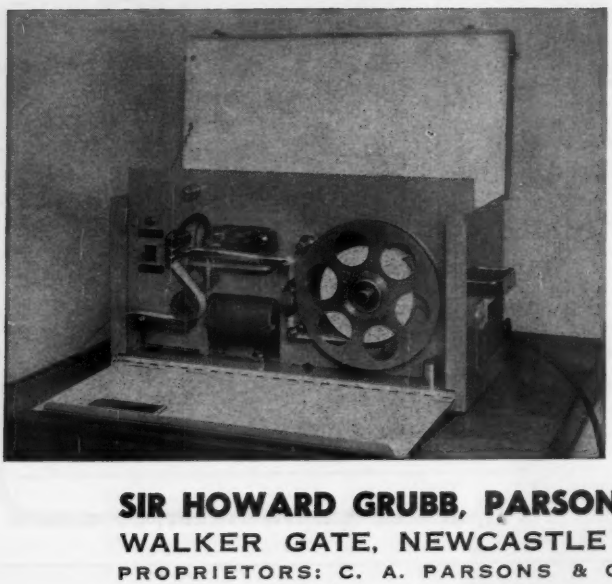

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taken up by the ferment is transferred to ferrocytochrome oxidase which becomes oxidized to ferricytochrome oxidase. The theory of the non-identity of the 'respiratory ferment' and cytochrome oxidase led them to postulate that the inhibitions of respiration by carbon monoxide and by cyanide are due to the combination of carbon monoxide with the divalent iron of the respiratory ferment and of cyanide with the trivalent iron of cytochrome oxidase. This theory, which ascribes to the 'respiratory ferment' the property of oxygenation very similar to that of hæmoglobin, has been previously examined and found unacceptable[9].

Warburg and Haas's[2] observations and Warburg's theory[3] of a stabilized oxygenated 'respiratory ferment' were also discussed and accepted by Oppenheimer and Stern[10] and by Stern[11], who found in these observations direct evidence for the formation of an oxygenated intermediate complex in all cases of oxidation by molecular oxygen of a ferrous to a ferric compound. In this sense an oxygenated ferrous cytochrome oxidase was also considered by Lemberg and Legge[12] when they discussed the mechanism of the catalytic activity of this enzyme. However, the real interest of this problem lies not in any very short-lived and thus undetectable oxygenated intermediate, the existence of which may be postulated on purely theoretical ground in all oxidation reactions involving molecular oxygen, but in Warburg's theory of stabilization of such an intermediate based upon direct spectroscopic observations of baker's yeast.

Occurrence of the absorption band at 583 mμ in baker's yeast. Of the numerous samples of commercial baker's yeast which I have examined spectroscopically at different times, only two samples, one obtained in 1936 and the other in 1940, revealed the presence of a weak absorption band between 580 and 585 mμ, and with these two samples I was able to confirm the main observations of Warburg and Haas[2]. The facts that the band at about 583 mμ is visible only during very strong aeration, and that it disappears when aeration is interrupted or when the yeast suspension is treated with carbon monoxide, indicate that the compound responsible for this band is in a ferrous oxygenated state. The band at 583 mμ can be observed even in a moderately aerated suspension provided it is kept at about 0° C. or treated with ethyl urethane. In the latter case this band is visible together with the band *b* of cytochrome. In yeast suspensions treated with cyanide the band at 583 mμ remains visible in the presence of the bands of reduced cytochrome but disappears on treating this suspension with carbon monoxide. Finally, in an aerated suspension treated with carbon monoxide the disappearance of the band at 583 mμ, as will be shown, is not directly connected with the appearance of a faint band between 590 and 600 mμ.

Critical examination of the theory of stabilization of an oxygenated 'respiratory ferment' or cytochrome oxidase. Study of the data so far available concerning the band at 583 mμ does not support the theory put forward by Warburg that this band belongs to an oxygenated intermediate complex of the 'respiratory ferment' or cytochrome oxidase. On the contrary, there is strong evidence in favour of the view that the compound responsible for this band is distinct from cytochrome oxidase. This evidence can be summarized as follows.

(1) The band at 583 mμ does not belong to a compound which has an important function in cellular respiration, since this band has been detected in very few strains of yeast and so far has not been observed in the highly respiring cells of *Torula utilis*, *Bacillus subtilis*, *Azotobacter chroococcum*, several species of *Acetobacter*, or in highly active wing muscle of insects, or in mammalian heart muscle preparations which are exceptionally rich in cytochrome oxidase.

(2) The diffuse absorption band which appears between 590 and 600 mμ when the suspension of yeast is treated with carbon monoxide is due to its combination with cytochrome oxidase (cytochrome a_3 [13]). It can easily be observed in cells and tissues which are completely devoid of the band at 583 mμ.

(3) If the band at 583 mμ were to belong, as was suggested by Warburg, to a ferrous oxygenated cytochrome oxidase complex within which the iron undergoes oxidation from a divalent to a trivalent state, cyanide, which forms a very stable compound with the latter, should accelerate and not slow down the deoxygenation of this complex and therefore the disappearance of this band.

(4) The stabilization of an oxygenated cytochrome oxidase even for a very short period, just sufficient for the spectroscopic detection of this complex, would greatly inhibit the catalytic activity of this enzyme.

(5) The reversible inhibition by carbon monoxide of the catalytic activity of cytochrome oxidase does not necessarily imply the existence of a stabilized oxygenated state of the enzyme, considering that carbon monoxide inhibits, in a similar manner, the catalytic activities of hæm and hæmochromogen compounds[14] in different oxidation reactions. The catalytic activity of phenol oxidases which are copper–protein compounds also shows a strong and perfectly reversible, although light-insensitive, inhibition by carbon monoxide[15,16].

Nature of the compound responsible for the absorption band at 583 mμ. The facts that this band appears when the yeast suspension is aerated, disappears when aeration is interrupted or when the suspension is treated with carbon monoxide, and persists together with the bands of reduced cytochrome in the yeast suspension treated with cyanide, suggest that the band at 583 mμ belongs to a ferrous oxygenated hæmoprotein such as oxyhæmoglobin. We shall refer to this compound as endogenous hæmoglobin, using here the term hæmoglobin in its widest sense, namely, as a hæmoprotein compound which in the ferrous state combines reversibly with molecular oxygen. In fact, the observations on yeast cells containing endogenous hæmoglobin are indistinguishable from those carried out on yeast suspensions containing added extracellular or exogenous hæmoglobin which were described in the first part of this article. However, it may be mentioned here that the α-band of the endogenous oxyhæmoglobin, like that of oxymyoglobin, lies nearer the red end of the spectrum than the α-band of blood oxyhæmoglobin. Since the endogenous hæmoglobin occurs in a very low concentration, only the α-band of its oxygenated derivative can be clearly seen, whereas the more diffuse absorption spectra of deoxygenated and carbon monoxide derivatives are not visible. Were the absorption spectrum of the carbon monoxide derivative visible, its α-band would be found in the region of about 575 mμ and not, as was suggested by Warburg and Haas[2], between 590 and 600 mμ.

That hæmoglobin, in a very low concentration, may occur in certain strains of baker's yeast and not in others is not surprising considering that samples of baker's yeast cultivated under different conditions may display very marked differences in their aerobic

and anaerobic metabolisms, their cytochrome systems, their enzymic equipment and many other properties[17–20]. The unexpected occurrence of hæmoglobin in a yeast suspension suggested in the first instance the possibility of its being only an accidental extracellular impurity. This possibility was, however, ruled out by the facts that the band at 583 mμ was of the same relative intensity to cytochrome bands throughout a fairly large specimen of pressed baker's yeast, that the yeast cells were thoroughly washed in a large amount of water before examination, and that the position of this band is 60–70 A. nearer the red end of the spectrum than the average position of the α-band of blood hæmoglobins.

Although hæmoglobin is found in all vertebrates, its apparently random distribution among other organisms is one of the peculiarities of this pigment. Thus, among the invertebrates hæmoglobin occurs somewhat haphazardly, being either completely absent in all representatives of large phyla, or present in only a very few species of a phylum, while absent in all other often very closely related forms. Even in the same organism the hæmoglobin content may show very great variation with the age of the organism or with its external conditions. The marked fluctuation in the hæmoglobin content of *Daphnia* has recently been investigated by Fox, Hardcastle and Dresel[21], who have shown that synthesis of hæmoglobin is favoured by oxygen deficiency. Moreover, a lake plankton species of *Daphnia*, which under natural conditions has colourless blood, was found to synthesize hæmoglobin when kept in an oxygen-deficient medium[21].

The occurrence of hæmoglobin in yeast cells is an interesting addition to the range of distribution of this pigment, which has already been recently widened by the unexpected discoveries of the pigment in *Paramecium*[22,23], in *Tetrahymena* (*Glaucoma*) *pyriformis*[23], and in nodules of leguminous plants[24–27]. Of special interest is the occurrence of hæmoglobin in *Neurospora* and *Penicillium*, dealt with in the following communication, especially since these moulds, like yeast (*Saccharomyces*), belong to the ascomycete fungi.

Biological significance of non-circulating hæmoglobin. The function of hæmoglobin in micro-organisms can scarcely be discussed without considering the more general problem of the biological significance of non-circulating hæmoglobin in cells and tissues of different organisms. Although this problem lies outside the scope of the present article, a few aspects of it will be briefly examined here.

There is now strong evidence in favour of the view that, at least in certain cases such as the myoglobin of red muscle[28,29] and the hæmoglobin of *Gastrophilus* larva[30], the pigment may provide a temporary store of oxygen which enables the cell to bridge over the intermittent increases in demand or decreases in supply of oxygen. However, the mode of life of micro-organisms, their small size, their high respiratory activity and the low concentration of hæmoglobin they contain preclude the possibility that their hæmoglobin may also act as a temporary store of oxygen.

The fact that the high catalytic activity of cytochrome oxidase is incompatible with the existence of a stabilized and spectroscopically visible oxygenated state of this enzyme does not by itself rule out the possibility that compounds capable of undergoing both oxygenation and oxidation may occur in Nature. Such compounds would naturally be very inefficient as either oxygen carriers or as oxidizing catalysts. In fact, no oxidizing catalyst can be obtained from hæmoglobin without abolishing its property of oxygenation. When hæmoglobin is denatured to yield a hæmochromogen it loses its characteristic property of an oxygen carrier and becomes an active oxidizing catalyst. However, under certain exceptional conditions, hæmoglobin may acquire the properties of an oxidizing catalyst without previous denaturation of the globin or separation of the latter from the catalytically active free hæm. Thus, on treating red blood corpuscles with phenylhydroxylamine, Warburg, Kubowitz and Christian[31] obtained methæmoglobin corpuscles, the oxygen uptake of which, in presence of glucose, was increased twenty-fold when compared with that of untreated corpuscles. Although the catalytic activity of methæmoglobin involves its reversible reduction to hæmoglobin, the latter, in the presence of oxygen, undergoes reoxidation to methæmoglobin instead of oxygenation to oxyhæmoglobin. According to Warburg and his co-workers, such unusual behaviour of methæmoglobin, although chemically unexplained, is of great importance for the theory of respiration. However, the study of the reactions of phenylhydroxylamine with hæmoglobin and its derivatives offered, as we have shown[32], a good chemical explanation of the phenomena observed by Warburg *et al.* Phenylhydroxylamine was found to reduce hæmatin and methæmoglobin to hæm and hæmoglobin, respectively, itself undergoing oxidation to nitrosobenzene. The nitrosobenzene then combines with hæm and hæmoglobin, forming well-defined corresponding nitrosobenzene compounds[32,33], which in the presence of oxygen undergo oxidation to free hæmatin and methæmoglobin, and in the presence of carbon monoxide give the carbon monoxide compounds of hæm and hæmoglobin. With oxyhæmoglobin phenylhydroxylamine first forms acid methæmoglobin; the reaction then proceeds further as described above. The hæmoglobin, which appears within corpuscles on the reduction of methæmoglobin by dehydrogenase systems, on combining with nitrosobenzene present in the corpuscles becomes protected from oxygenation to oxyhæmoglobin but not from reoxidation to methæmoglobin or combination with carbon monoxide[32].

Discussion of the biological significance of non-circulating hæmoglobin brings us back once more to the theory of the Japanese workers[1–6] concerning the function of the 'respiratory ferment' to which they ascribed the property of reversible oxygenation similar to that of hæmoglobin. However, it is difficult to visualize the necessity for a hæmoglobin-like component to form a link between molecular oxygen and cytochrome oxidase without making two assumptions, for which no evidence is as yet available, namely: (1) that the oxygen molecule on dissociation from an oxygenated complex has a somewhat higher oxidizing potential than ordinary molecular oxygen; and (2) that cytochrome oxidase, although autoxidizable, reacts more readily with oxygen on its liberation from such a complex than with oxygen dissolved in the surrounding medium. Were these assumptions proved correct, we should have an explanation of the possible function of intracellular non-circulating hæmoglobin, especially in cells where it cannot act as a temporary store of oxygen.

Finally, the fact that hæmoglobin may appear in very small and often variable concentrations in

certain cells does not necessarily imply that it plays an active part in the respiration of these cells. Considering that most of the cells of aerobic organisms are capable of synthesizing hæmatin compounds[1], it is the availability of a suitable protein that probably governs the distribution of hæmoglobin in Nature. Since hæmoglobins of different origin may show very great variations in the chemical structure of their proteins, it is possible that within a rapidly growing cell synthesizing a great variety of proteins a suitable protein may appear which, on combining with hæm, also actively synthesized by the cell, would impart to its iron the remarkable property of combining reversibly with molecular oxygen.

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Hæmoglobin in Moulds: *Neurospora crassa* and *Penicillium notatum*

SPECTROSCOPIC examination of mycelia of *Neurospora crassa* shows that the disappearance of the absorption bands of reduced cytochrome in the presence of oxygen is accompanied by the appearance of two new bands lying at about 583 and 545 mμ. Although these bands can be detected in the wild type of *Neurospora* as well as in different strains of this mould described by Mitchell, Mitchell and Tissières[1], they are more prominent in their mutant strain *C*117. The description of the compound responsible for these bands will therefore be based mainly upon the study of this strain of *Neurospora* grown in a well-aerated fluid synthetic medium[2].

Mycelium collected from a culture about five days old is washed several times in water, being each time strained and pressed out through muslin. The material thus obtained is in the form of a compact felt of mycelium which, since it is not easily aerated, shows the absorption bands of reduced cytochrome. However, the felt can be saturated with oxygen by a method previously used for the oxygenation of thick slices of muscle[3] (see also previous communication). A thick felt of mycelium is placed over the condenser of the microscope fitted with a micro-spectroscope ocular and compressed until it is translucent enough to show strong bands of reduced cytochrome. The mycelium is then treated with hydrogen peroxide which, on being decomposed by catalase, liberates oxygen in the form of minute bubbles which are kept imprisoned within the felt. The excess of froth is easily removed by slightly compressing the felt with a spatula. Under these conditions it can be seen that the absorption bands of reduced cytochrome rapidly disappear and are replaced by two new bands: α- 583 mμ and β- 545 mμ. As the oxygen is used up, these two bands gradually fade while the bands of reduced cytochrome reappear. Partial oxygenation of the mycelium, without the use of hydrogen peroxide, is obtained when a thick felt of mycelium is quickly compressed and released. Cytochrome bands may then be seen to decrease in intensity, and sometimes even to disappear, while the bands at 583 and 545 mμ reappear. However, within a few seconds the absorption spectrum reverts to the original state, showing only the bands of reduced cytochrome.

All further work on the compound responsible for the bands at 583 and 545 mμ was carried out upon cell-free preparations which were obtained by grinding the mycelium in a cold mortar with 0·5 parts of sand and 0·3–1 part of water and centrifuging off the solid residue which carries with it most of the cytochrome. The supernatant fluid was further clarified by high-speed centrifugation (15,000–20,000*g*) for a period of one to two hours in a refrigerated centrifuge to give an opalescent orange-yellow solution, which on aeration shows the same two distinct absorption bands at 583 and 545 mμ. If this solution is left standing at room temperature these bands gradually disappear and, within twenty to sixty minutes, are replaced by very feeble bands of the reduced components of cytochrome which are probably associated with insoluble material still present in the solution and responsible for its opalescence. On passing air through this solution the bands of cytochrome are replaced by the bands at 583 and 545 mμ, which rapidly disappear on treating the solution with sodium dithionite ($Na_2S_2O_4$) or on bubbling pure nitrogen through it. In both cases they are replaced by weak bands of reduced cytochrome.

On passing through the solution a current of a gas mixture composed of carbon monoxide and oxygen ($CO/O_2 = 4$) the bands at 583 and 545 mμ are replaced by two bands at 574 and 539 mμ; the original bands reappear, however, when the solution is vigorously aerated. Finally, the two bands (583 and 545 mμ) also disappear when the solution is treated with potassium ferricyanide but without being replaced by any detectable bands in the visible region of the spectrum.

The facts that the new absorption bands at 583 and 545 mμ appear when the solution is aerated and disappear when it is deprived of oxygen or treated

with potassium ferricyanide and are replaced in presence of carbon monoxide by two diffuse bands at about 574 and 539 mμ indicate that these bands belong to an oxygenated ferrous hæmoprotein such as oxyhæmoglobin or oxymyoglobin. This pigment appears in the mycelium on the third day of cultivation, reaches its maximum concentration on the fifth day and then gradually disappears.

The concentration of oxyhæmoglobin in intact fresh five-days old mycelium is of the same order of magnitude as that of some components of cytochrome. In the opalescent cell-free extract of mycelium its concentration can be determined precisely by matching the absorption spectrum of a well-aerated extract with that of a standard solution of oxymyoglobin. The estimation is carried out with a microspectroscope outfit provided with a double wedge trough[4]. The total hæmatin content of the extract can be similarly estimated by transforming all the hæmoproteins it contains into pyridine hæmochromogen, the absorption spectrum of which is matched with a standard solution of pyridine hæmochromogen prepared from pure hæmin. Assuming that the equivalent weight of hæmoglobin of *Neurospora* is about the same as that of mammalian hæmoglobin or myoglobin, namely, 17,000, the extract of *Neurospora* was found to contain about 10 mgm. per cent of hæmoglobin. The total hæmatin content of this extract estimated as pyridine hæmochromogen was, however, higher than could be accounted for by the hæmoglobin and the residual cytochrome. In fact, the hæm of hæmoglobin represented only about 60 per cent of the total hæm present in the extract. The main part of the non-hæmoglobin hæm appears to be in the form of free hæm which is derived, as will be shown presently, from hæmoglobin as well as from some of the components of cytochrome.

Of other moulds we have so far only made a systematic study of *Penicillium notatum*, which was cultivated and harvested in the same way as *Neurospora* to give a compact felt-like mass of mycelium. When examined with a microspectroscope it shows strong absorption bands typical of reduced cytochrome. On rapid compression and release of the felt or on treating it with hydrogen peroxide, the absorption bands of reduced cytochrome disappear and are replaced by the bands at 583 and 545 mμ, although the second band is not always visible. The absorption band at 583 mμ can also be seen in mycelium resuspended in water and vigorously aerated. The fact that this band appears on oxygenation, disappears on deoxygenation or on treating the suspension with quinone, and is shifted to 574 mμ in presence of carbon monoxide, shows that it belongs to an oxygenated ferrous hæmoprotein or oxyhæmoglobin. Unfortunately, the attempts to obtain a hæmoglobin-containing clarified extract of *Penicillium* were unsuccessful, since most of the hæmoglobin in the crude extract was either enzymically destroyed or attached to the insoluble fraction.

One of the important conditions for the study of hæmoglobin and the cytochromes of moulds is that it must be carried out upon material freshly obtained and that only submerged and properly aerated mycelium should be collected and not the mycelium which, owing to vigorous aeration, may have been projected out of the medium and be found attached to the walls of the vessels above the level of the fluid. In fact, mycelium which remains outside the aerated nutrient medium even at low temperatures (+ 2° C.) undergoes autolysis accompanied by very marked changes in its absorption spectrum. The absorption bands both of hæmoglobin and the cytochromes (except cytochrome *c* of *Penicillium*) gradually diminish in intensity, while two somewhat diffuse but strong bands appear at about 587 and 548 mμ. Although these absorption bands lie very near those of oxyhæmoglobin, spectroscopic study of moulds or their extracts under different conditions has revealed that the bands belong to free protohæm (ferroprotoporphyrin). The evidence in support of this view can be summarized as follows: (1) they show great similarity to the absorption bands of hæm which are obtained on reducing an alkaline solution of hæmin with sodium dithionite ($Na_2S_2O_4$); (2) on aeration these bands disappear and very slowly reappear when aeration is stopped; (3) they are intensified on treating the mould or its extract with a reducing agent ($Na_2S_2O_4$); (4) in the presence of carbon monoxide they are replaced by much stronger bands lying at about 567 and 537 mμ; (5) on addition of imidazole these bands are replaced by the very strong bands of imidazole hæmochromogen. This reaction is of special interest since hæmoglobin, oxyhæmoglobin and the components of cytochrome do not react with imidazole.

There is very little doubt that the free hæm which appears in moulds originates from hæmoglobin and some of the components of cytochrome by an enzymic degradation of these hæmoproteins which accompanies the autolysis of the mycelium. It is somewhat surprising that the hæm does not appear to combine with some of the nitrogenous substances or denatured proteins present in the mycelium to form hæmochromogens. It follows that either no suitable substances are available to react with the hæm or that the conditions are not favourable for such a reaction to take place. However, in some specimens of moulds the intensification of the absorption bands of hæm and their displacement towards the blue end of the spectrum (to 576 and 537 mμ) indicate the possibility of a complex formation between a protein and the hæm whereby only the porphyrin of the hæm is linked to the protein. Such complexes would resemble the hæm–albumin compound.

In old mycelia the free hæm itself undergoes a further degradation which consists in the liberation of iron and the appearance of free porphyrin, which can easily be recognized on direct spectroscopic examination of the mycelium or of an extract obtained by treating it with a mixture of ether and glacial acetic acid. All these changes are more marked and develop more rapidly in the mycelium of *Penicillium* than in that of *Neurospora*.

In some samples of moulds these degradation products may even be detected during growth and proliferation of the mycelia. Owing to their distinctive properties, however, their presence does not interfere with the study of the unchanged hæmoproteins such as hæmoglobin and the components of cytochrome.

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LETTERS TO THE EDITORS

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Isolation of Penicillaminic Acid and D-α-Aminoadipic Acid from Cephalosporin *N*

CEPHALOSPORIN *N*, an antibiotic produced by a species of *Cephalosporium*, was recently reported to be a new type of penicillin. The physical properties of this substance indicated that it contained a basic group as well as acidic groups[1]. The purest preparation of cephalosporin *N* so far obtained, which appears from analysis of a counter-current distribution curve to be at least 50 per cent homogeneous, has now been found to yield D-α-aminoadipic acid on hydrolysis. While L-α-aminoadipic acid is known to occur in Nature[2,3], the D-isomer does not appear to have been isolated previously from a natural source.

The preparation of cephalosporin *N* was hydrolysed in *N* hydrochloric acid at 100° for six hours, and the hydrolysate was separated by electrophoresis into neutral and acidic fractions.

The neutral fraction was oxidized with bromine water and the acidic material formed was again separated by electrophoresis. On treatment with charcoal and crystallization from aqueous acetone this material yielded colourless prisms of penicillaminic acid (ββ-dimethylcysteic acid) (found: C, 30·6; H, 6·0; N, 6·9 per cent; $C_5H_{11}O_5NS$ requires: C, 30·7; H, 5·6; N, 7·1 per cent).

The acidic fraction contained an amino-acid which behaved on two-dimensional paper chromatograms like α-aminoadipic acid. This amino-acid was obtained in a homogeneous state by chromatography on a column of 'Amberlite *XE*-59', eluting with 0·2 *M* ammonium acetate buffer, *p*H 5[4]. It crystallized from water, melting point 205–207°, $[\alpha]_D^{20} = -26°$ ($c = 1$ in 6 *N* HCl) (found: C, 44·2; H, 7·0; N, 9·0; $C_6H_{11}O_4N$ requires: C, 44·7; H, 6·9; N, 8·7).

This substance showed no depression in melting point on mixing with a sample of authentic D-α-aminoadipic acid. Electrometric titration showed the presence of two acidic groups of *pK* 2·2 and 4·4 respectively and a basic group of *pK* 9·8. An X-ray powder photograph was kindly taken by Dr. D. Hodgkin, who reported that it was identical with a photograph of authentic D-α-aminoadipic acid. Oxidation with chloramine-*T*[5] and addition of 2:4-dinitrophenyl hydrazine to the resulting solution yielded an acidic 2:4-dinitrophenylhydrazone, melting point 130–131°, which appeared to be derived from γ-aldehydo-*n*-butyric acid (found: C, 44·8; H, 4·2; N, 18·4 per cent; $C_{11}H_{12}O_6N_4$ requires C, 44·5; H, 4·7; N, 18·9 per cent). The same compound was formed on oxidation of DL-α-aminoadipic acid.

The preparation of cephalosporin *N* contains a basic group of *pK* 9·8 and forms a dinitrophenyl derivative with fluorodinitrobenzene. This derivative yields a compound on hydrolysis which behaves like DNP-α-aminoadipic acid on paper chromatograms. It is therefore concluded that the α-amino group of α-aminoadipic acid is free in the active material. Since the *pK* values of the basic group in this material and in the amino-acid are very similar, it appears likely that α-aminoadipic acid is linked to the rest of the molecule through its δ-carboxyl group.

The evidence so far available is not incompatible with the assumption that cephalosporin *N* is an α-aminoadipyl derivative of the essential core of the penicillin molecule. A compound of this structure would be expected to have the physical properties of the antibiotic. The existence of glutamyl and aspartyl derivatives is also possible. Traces of glutamic acid and aspartic acid were liberated from the purest preparation of cephalosporin *N* on hydrolysis with *N* hydrochloric acid at 100°, and larger amounts from cruder preparations.

The presence of a free amino group obviously makes it possible to prepare derivatives of cephalosporin *N* by reactions which cannot be applied to benzylpenicillin. It is of interest that the DNP-derivative, which, unlike the parent substance, can be extracted into ether or ethyl acetate, has a higher activity than the latter against *Staph. aureus* and a much lower activity against *Salm. typhi*.

We are indebted to Dr. J. P. Greenstein for a sample of synthetic D-α-aminoadipic acid, to Dr. Borsook for a sample of L-α-aminoadipic acid, and to Drs. Fones, Gaudry and Work for samples of DL-α-aminoadipic acid.

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A Colorimetric Method, based on Metallic Complex Formation, for the Detection of Aureomycin in Presence of Amino-Acids and Proteins

EXPERIMENTS involving the feeding of aureomycin to animals are now so common that it would be an advantage to have a rapid and reliable chemical method for its detection in body fluids and similar media. This is the more desirable since microbiological methods of assay are not easy to carry out because of the instability of the antibiotic in ordinary bacteriological media, even at 25°[1,2]. There is one remarkable chemical property of aureomycin, apparently not yet recorded in the literature, which might be made use of to this end, namely, its ability in alkaline solution to form stable, yellow complexes, soluble in *n*-butanol, with certain divalent cations only, notably Mg, Ca, Co, Ni, Cu and Sr. Zn, Cd, Mn, Ba, Hg and Pb do not form stable coloured complexes. Aureomycin alone gives, of course, a yellow colour with excess of ammonia or caustic soda, but this fades quite quickly and irreversibly at 30°, a purple fluorescence developing in its place. Shaking with *n*-butanol then extracts no colour.

Many divalent cations also form stable complexes with amino-acids[3], and hence their colours (if any) with aureomycin may not be stable in bacteriological media. It happens, however, that the affinity of aureomycin for Ca^{++} and Co^{++} is so great that this limitation is scarcely felt with these cations. Thus, to demonstrate the calcium or cobalt colours in

presence of other divalent cations, the following final concentrations (μgm./ml.) are suitable: pure aureomycin hydrochloride, 200–400; 'Bactogelatine' (calcium-free), 1,000; Ca^{++} or Co^{++}, 20–40. Ammonia or sodium hydroxide is added last of all to a final concentration of about 0·25 or 0·04 *M* respectively. The mixture is kept at 30° for 90 min. and then shaken with enough *n*-butanol to give a distinct top layer. A yellow colour in the top layer only denotes calcium; in both layers, cobalt. The 'Bactogelatine' in conjunction with ammonia will suppress the colours otherwise given by Mg^{++}, Cu^{++} or Ni^{++}; in conjunction with sodium hydroxide it will also suppress the colour due to Sr^{++}. It has practically no effect, however, even after several hours standing, on the colours given by Ca^{++} or Co^{++}. The cobalt colour is much browner than the calcium colour, which is a pure yellow.

For the detection of aureomycin, calcium is the metal of choice since its complex is completely extracted from aqueous solution by one shaking with *n*-butanol. (The $CaCl_2$ complex of the structurally related antibiotic terramycin has already been described by Regna *et al.*[5].) It is quite easy to detect 20 μgm./ml. of aureomycin in a solution containing both 'Bactogelatine' (0·1 per cent) and 'artificial' casein hydrolysate (0·1 per cent, made according to the directions of Norén[4]) by adding a drop or two of 0·2 per cent calcium chloride solution, using sodium hydroxide as the alkali rather than ammonia, and incubating at 30° for 15 min. only. An aureomycin control without calcium chloride and a calcium control without aureomycin give absolutely no colour in the top layer. Such a solution corresponds to a bacteriological medium. Alternatively, one may use 1 per cent peptone water which, however, usually contains enough calcium already to give the test when aureomycin is added.

It should be mentioned that the calcium-free 'Bactogelatine' ('Difco') specimen here used was *sui generis*. All other specimens of bacteriological gelatin by other suppliers seemed to contain calcium. Likewise, two commercial specimens of acid hydrolysed casein also contained enough calcium to give the test. On the other hand, among scores of commercial specimens of amino-acids only two—one out of several of methionine and one of cysteine hydrochloride—gave the test in absence of added calcium chloride, and so it was possible to make up a calcium-free 'artificial' casein hydrolysate to simulate a bacteriological medium.

In addition, aureomycin may be used as a reagent for detecting traces of calcium in presence of magnesium and of cobalt in presence of nickel, and may thus be of some use in analytical chemistry.

I am indebted to Dr. A. T. Mennie, medical director, Lederle Laboratories Division, Cyanamid Products, Ltd., Bush House, London, W.C.2, for arranging for a supply of pure aureomycin hydrochloride to be sent to this Institute for calf-feeding experiments.

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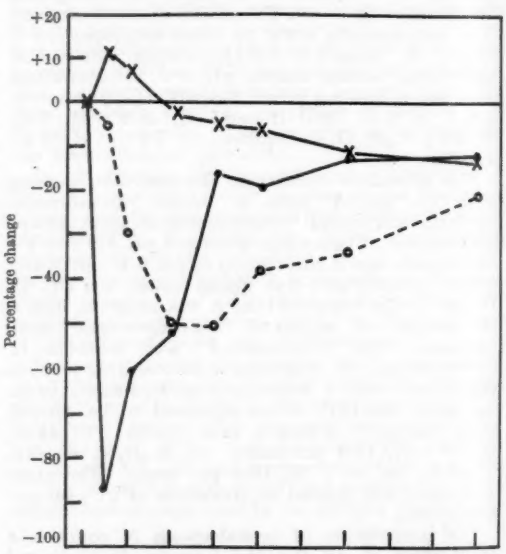
Effect of Insulin on the Adrenergic Amines of Blood

It is generally assumed that the stimulation of adrenalin secretion which is observed after insulin administration is a reaction not caused by insulin itself but by the hypoglycæmia which it produces. It has also often been claimed, with and without supporting evidence, that insulin hypoglycæmia is accompanied by hyperadrenalinæmia. This claim is not correct, as has recently been shown[1]. The intravenous injection of insulin in fasting subjects leads to an immediate and pronounced drop of the level of adrenergic amines in plasma which precedes the fall of the blood sugar. Likewise, in the recovery period, the return of the level of adrenergic amines to the norm precedes the rise of the blood sugar curve. If coma doses of insulin are injected the plasma-level of adrenergic amines remains depressed, until the coma is terminated by glucose administration. The effect of insulin is also observed, although in mild and modified form, if the development of hypoglycæmia is prevented by a preceding glucose ingestion.

The method which was used in these studies did not permit a differentiation between adrenalin and noradrenalin, but a modification has recently been developed[2] with which this has become possible. Its application to the insulin effect has shown that the drop is entirely or almost entirely accounted for by the disappearance of adrenalin from plasma. The level of noradrenalin remains stationary or is, in some cases, slightly reduced. A typical result is shown in the accompanying figure. The concentration of adrenalin and noradrenalin in red blood cells is unchanged or diminished.



Percentage changes of the concentrations of adrenalin, noradrenalin and glucose in plasma after the intravenous injection of insulin (0·1 unit/kgm.).

●——●: adrenalin concentration changes; initial concentration 1·56 μgm./litre of whole blood. ×——×: noradrenalin concentration changes; initial concentration 5·82 μgm./litre of whole blood. ○- - - -○: glucose concentration changes; initial concentration 75·5 mgm. per cent

It must be assumed, therefore, that under the influence of insulin the fixation of adrenalin in the tissues is increased, and this has been clearly demonstrated by Hökfelt[3]. The increased secretion of adrenalin after insulin administration may thus be a reaction to compensate for the lowering of the plasma adrenalin-level, rather than an effect of hypoglycæmia. Euler and Luft[4] have recently shown that insulin causes an increased urinary excretion of adrenalin, but not of noradrenalin. This observation would be difficult to reconcile with the reduction of plasma adrenalin-levels, unless it is assumed that the adrenergic amines of urine exist largely in the conjugated form. The conjugated amines would not be estimated by the method used for the analysis of blood.

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Extremely High Alkaline Phosphatase Activity in the Vaginal Mucus of the Cow

In the course of an investigation on the phosphatase content of the vaginal smear of some non-pregnant cows and heifers, extremely high alkaline phosphatase activity was observed in the mucus at regular intervals corresponding with the ovarian cycle of the animal. The highest values were found on the day that mucus secretion begins, two days before the visible signs of heat (bellowing, unrest, willingness to copulate). On that day a relatively small but highly active amount of mucus is secreted. A second period of relatively high activity of the mucus is often seen between the eighth and the twelfth day *post œstrum*. The activity is rather variable in different individuals and the daily variations may be great, especially in periods of irregular mucus secretion.

The diagram indicates the concentration of alkaline phosphatase in the mucus of a normal, healthy cow. Phosphatase activity is expressed in King and Armstrong units[1] per 100 gm. of mucus. In our first series of experiments, the mucus was homogenized and dissolved in water; later, we used a 0·06 per cent magnesium chloride solution in order to obtain maximal activation. Since the amount of mucus which was secreted daily could not be estimated, the diagram does not give the total amount of phosphatase produced. During œstrum, mucus secretion is abundant, but the clear mucus is only slightly active.

Alkaline Phosphatase Activity (King and Armstrong Units per 100 gm.) in the Vaginal Mucus of Heifers

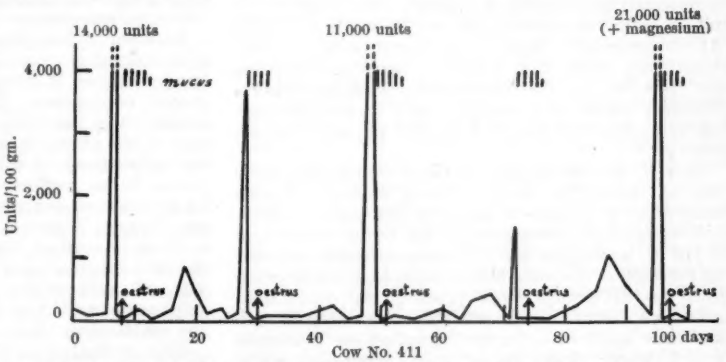
Date	21/4/52	23/4/52	28/4/52	1/5/52	4/5/52
No. 817	27,600	100*	100	86	—
,, 818	3,200	1,890	11,040	5,180	460
,, 819	1,040	220	200	104	290
,, 820	6,000	26,200	100*	610	3,000
,, 821	7,500	3,310	1,520	510	800
,, 822	9,500	1,240	320	760	700

* = œstrum.

Days of abundant secretion are indicated in the diagrams by vertical lines. The rapid fall in activity just before œstrum is an effect of dilution and cannot be ascribed to instability of the enzyme, since a sample of highly active mucus (14,000 King and Armstrong units per 100 gm.) retained its full activity while stored at room temperature for three days.

Large amounts of alkaline phosphatase are secreted by heifers, especially in the period of first œstrum. A characteristic picture of the very high and variable activities found in the mucus of six heifers is given in the accompanying table.

The alkaline phosphatase diagram probably gives a picture of the permeability of the vaginal epithelium and of the amount of enzyme stored in the mucosa. The influence of castration, hormones and diet (feeding of phosphates) is now under investigation. In a case of corpus luteum persistens, very low alkaline phosphatase values were found. Stable dry enzyme preparations, containing 50–100 per cent of the original activity, can be obtained from the mucus by precipitation with cold ethanol or acetone. Our most active preparations, 40–50 King and Armstrong units per mgm. nitrogen, showed a positive biuret, a strong Molisch and a negative phosphorus reaction.



Alkaline phosphatase activity (in King and Armstrong units per 100 gm.) in the vaginal mucus of a cow during five ovarian cycles. Days of abundant mucus secretion are indicated by short vertical lines; days on which full œstrus was observed are marked by an arrow

I am grateful to Dr. J. I. Terpstra, at whose instigation this study was undertaken, and to Mr. W. A. Eisma and Miss M. E. Goedkoop for veterinary and technical assistance.

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Isolation of a Mixed Disulphide of Glutathione and Cysteinylglycine from a Partial Hydrolysate of Glutathione

Glutathione, γ-glutamylcysteinylglycine, can easily be split into glutamic acid and cysteinylglycine by mild acid hydrolysis[1], and even without acid by heating in a water solution[2]. The tripeptide has therefore been used as material for the preparation of cysteinylglycine. In order to prepare this dipeptide for a microbiological purpose, the latter of the two methods was tried.

Glutathione, dissolved in distilled water, was hydrolysed for five days at 62° C. The cysteinylglycine and possibly unhydrolysed glutathione were precipitated as their mercaptides with mercuric sulphate. The precipitate was washed with water and decomposed with gaseous hydrogen disulphide. The mercuric sulphide was removed by centrifugation and the supernatant neutralized with barium hydroxide. After evaporation of the solution to a few millilitres, precipitation was made with absolute alcohol. During storage the SH-groups originally present were oxidized (test with sodium nitroprusside). In order to examine whether the hydrolysis was complete, a one-dimensional descending chromatogram was developed in the usual manner with acetic acid : *n*-butanol : water (1 : 4 : 5) and Whatman No. 1 paper. More than one component was detected, but the resolution of the mixture was unsatisfactory, and therefore electrophoresis on paper was tried according to the method of Kunkel and Tiselius[3]. The run was made in acetate buffer (*p*H 4·5, μ 0·05) with about 0·2 mgm. of the substance on Munktell 20 paper and using a potential gradient of 5 V./cm. for six hours. The position of the material was determined by treating the paper with ninhydrin solution. As seen from the illustration (row No. 2), three spots could be detected on heating the paper, two of which (*B* and *C*) travelled towards the anode, while the third (*A*) was immobile. Spot *C* was found to be oxidized glutathione, since this substance gave an identical spot (row No. 1 in the illustration). Judging from its yellowish colour and position, spot *A* was cystinyl-*bis*glycine, and this was confirmed by paper chromatography.

Spot *B* was eluted from a paper run in the same way as above, its position being determined with ninhydrin on a narrow strip of the paper. After hydrolysis of the component in 6*N* hydrochloric acid at 110° C. overnight, a paper chromatogram revealed the presence of the same amino-acids as in glutathione. Since no SH-groups were present, the component must be a disulphide. It was therefore oxidized with performic acid[4] and chromatographed on Whatman No. 1 paper with acetic acid : *n*-butanol : water (1 : 4 : 5). Two spots were detected, the faster one being ($CySO_3H$).Gly and the slower one, γ-Glu.($CySO_3H$).Gly, the sulphonic acid derived from glutathione. Synthetic samples of these peptides were used as references. The unknown compound was thus a mixed disulphide of glutathione and cysteinylglycine,

γ-Glu.(CyS).Gly
|
(CyS).Gly.

Since both the glutathione and the cysteinylglycine had been isolated in their reduced forms from the hydrolysis mixture, this mixed disulphide must in this case have been formed secondarily by oxidative coupling of the peptides during storage. It might also be formed as an intermediate product in the hydrolysis of oxidized glutathione. A similar mixed disulphide has also been prepared from glutathione and cystein by oxidation with perhydrol at *p*H 7·5. It could be separated from the reaction mixture in the same way as above.

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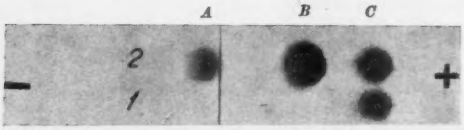

Electrophoresis on paper of a partial hydrolysate of glutathione: (1) oxidized glutathione; (2) partial hydrolysate of glutathione

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Enzymatic Hydrolysis of Urinary Neutral 17-Ketosteroid Conjugates

It is generally accepted that urinary steroids are excreted almost entirely in the form of water-soluble conjugates with glucuronic and sulphuric acids. Acid hydrolysis has been extensively used to liberate free steroids from these conjugates; but the conditions necessary for complete hydrolysis are such that considerable changes occur within the steroid molecules themselves, particularly the substitution of the hydroxyl group of androst-5-en-3-β-ol-17-one (dehydro*iso*androsterone) by chlorine.

β-Glucuronidase preparations have been shown to split steroid glucuronides and have been applied to the hydrolysis of corticosteroid, œstrogen and keto-steroid conjugates. The application of sulphatase concentrates has been mainly confined to the liberation of the phenolic œstrogens from their sulphates; the sulphatases of microbiological origin have been shown to be ineffective for hydrolysing the neutral 17-ketosteroid conjugates[1]. Henry and Thevenet[2] and Henry, Thevenet and Jarrige[3] have, however, recently described the total hydrolysis of urinary steroid conjugates and the hydrolysis of the potassium salt of androst-5-en-3-β-ol-17-one sulphate with sulphatase and β-glucuronidase preparations from the edible snail (*Helix pomatia*).

The recently published work of Dodgson and Spencer[4] has shown the high β-glucuronidase and phenol sulphatase activity of extracts of the visceral hump of the common limpet (*Patella vulgata*). We have found that an extract of the visceral hump of this species of mollusc hydrolysed a sufficiently large amount of the neutral 17-ketosteroid conjugates present in urine to indicate that a steroid alcohol sulphatase was active. The extract was prepared from acetone-dried visceral hump by extraction with 0·1 *N* potassium chloride at *p*H 8·0, precipitation by half saturation with ammonium sulphate, followed by dialysis and freeze-drying of the precipitate.

This extract, when incubated with normal male urine at *p*H 5·0 for periods up to 96 hr., released amounts of 17-ketosteroids exceeding 90 per cent of

Table 1. Release of 17-Ketosteroid-like Substances from a Normal Male Urine by Acid Hydrolysis and Enzymatic Hydrolysis

Volume of urine (ml.)	Treatment	17-Ketosteroids released (crude totals in μgm.)
25	Acid hydrolysis	173
	Enzymatic hydrolysis (50 mgm.* enzyme concentrate at *p*H 5·0, 37° C.)	
25	(*a*) Incubated for 24 hr.	92
25	(*b*) Incubated for 77 hr.	167
25	Urine incubated at *p*H 5·0 and 37° C. for 77 hr. without enzyme	6

Table 2. Enzymatic Hydrolysis of the Sodium Salt of Androst-5-en-3-β-ol-17-one Sulphate

Substrate	Treatment	17-Ketosteroid released	
		Crude total (μgm.)	Per cent
Sodium salt of androst-5-en-3-β-ol-17-one (80 μgm./ml.)	2 hr. at *p*H 4·8, 37° C. Blank	3	0·75
,,	1 hr. at *p*H 4·8, 37° C. + enzyme (10 mgm.*)	38	9·5
,,	2 hr. at *p*H 4·8, 37° C. + enzyme (10 mgm.*)	77	19·2

* The alcohol sulphatase activity of the enzyme preparation was estimated by measuring the rate of release of androst-5-en-3-β-ol-17-one from the sodium salt of androst-5-en-3-β-ol-17-one sulphate, and will be described in detail elsewhere.

that obtained by acid hydrolysis performed according to the method of Callow. Table 1 gives the detailed results of a typical experiment. Moreover, the extracts so obtained were considerably less contaminated by urinary chromogens than after acid hydrolysis.

Fractionation by partition chromatography[2] of the urinary steroid complex liberated by enzyme action showed a marked absence of the 'artefact' peak, particularly 3-β-chloroandrost-5-en-17-one. The peak corresponding to androstan-3-α-ol-17-one (androsterone) was obtained in similar yield by both enzymatic and acid hydrolysis of aliquots of the same urine.

The same extracts of *P. vulgata* have been shown to contain a β-glucuronidase by estimation of the rate of liberation of glucuronic acid from borneol glucuronide. An optimum value of *p*H 4·0 was observed for this reaction. Similarly, these extracts were shown to hydrolyse the pure sodium salt of androst-5-en-3-β-ol-17-one sulphate (Table 2), the liberated free ketosteroid being estimated by means of the Zimmermann reaction. The optimum *p*H for this reaction was in the region of 4·8–5·0.

Differences between the rates of enzymatic hydrolysis of urinary steroid conjugates and those obtained using pure substrates pointed to an inhibition by urinary constituents. A private communication from Drs. Dodgson and Spencer (in the press) directed our attention to their work on the inhibition of the phenol sulphatase from *P. vulgata* by urine, in which they showed that both sulphate and phosphate ions inhibit the reaction of their enzyme. We have found that removal of sulphate and phosphate ions from the urine, as they suggest, considerably increased the rate of hydrolysis of urinary neutral 17-ketosteroid conjugates.

Further details of this work will be published elsewhere.

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Potential Constants of Diacetylene

A misinterpretation of the vibrational spectrum of diacetylene ($HC{\equiv}C{-}C{\equiv}CH$)[1] led to very low values of the potential (force) constant corresponding to the central carbon–carbon bond. Although some justification was offered for this low value[2,3] the recent experimental work of Jones[4] and a correlation study of diacetylene and similar molecules[5] led to the conclusion that the previous assignment of the fundamental frequencies and, therefore, the potential constants obtained from them, must be discarded. Several recent publications[1,4,6] agree in giving a value for the central carbon–carbon bond-stretching potential constant which is substantially higher than the value corresponding to a single bond.

A normal co-ordinate treatment has now been carried out for diacetylene by using the frequencies given by Jones[4], without transferring any potential constant from similar molecules. Different sets of constants were obtained, corresponding to values of the C—H potential constant in a range close to the corresponding value in acetylene. The value of the central-bond potential constant has been established in this way between 6·6 and 6·8 md./A. Coulson and Longuet-Higgins[7] have given expressions for the stretching-potential constant of a bond in conjugated hydrocarbons; and Coulson[8] has also plotted curves relating the mobile bond-order to the atomic radius of carbon for different values of the coefficient of orbital mixing. In diacetylene, where the σ-bond is of *sp* type, the bond order is 0·70, corresponding to a radius of 0·68 A. If we use a value of 6·7 md./A. for the potential constant, the corresponding self-polarizability is $-\ 2{\cdot}20\ (\text{md./A.})^{-1}$, which is definitely smaller (in absolute value) than it would have to be to justify a drastically low value of the potential constant, as reported previously. Recently, Longuet-Higgins and Burkitt[6] have calculated a potential constant of 7·97 md./A., in qualitative agreement with our results, although, in terms of the present normal co-ordinate treatment, the latter figure for the potential constant seems too high. It does not seem possible that the neglect of the anharmonicities and very small interaction constants may produce such a large difference.

Coulson and Longuet-Higgins[8] have pointed out the great difficulties involved in the theoretical calculation of mobile bond-orders and bond polarizabilities. The method used here may provide an independent check for such calculations. A more

detailed account of the work outlined above will be published in the *Journal of Chemical Physics*.

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Effect of Thyroxine on Coenzyme *A* Levels

Attempts to establish the mechanism and site of action of thyroxine upon peripheral tissues have occupied the interest of a number of investigators, and a detailed account of the various areas of study has been presented in Barker's[1] review. Of the various possibilities suggested, it may be mentioned that thyroxine has been stated to cause a release of co-enzymes, protein carriers or other substances needed for many of the energy-transforming processes in cells[2,3]; but neither the mechanism of release nor the source of these materials is clear. Martius and Hess[4] have suggested that thyroxine acts as an uncoupling agent.

In investigating the peripheral action of thyroxine it would appear logical to study a system which has been demonstrated to exert an influence upon the basic economy of the body. Recent developments in the establishment of the function of coenzyme *A* have demonstrated the fact that a number of reactions which previously had been shown to be influenced by the thyroid state are coenzyme *A*-dependent. This suggests that there may be a relationship between coenzyme *A* and thyroxine.

With these considerations in mind, it was decided to determine what influence, if any, the thyroid exerted upon the coenzyme *A*-levels in liver, heart, brain and intestine. The experimental animals used were white male Wistar rats of approximately 90–150 gm. weight. Ten of these animals were thyroidectomized with iodine-131 and then after an appropriate interval separated into two groups: *A*, controls; and *B*, animals treated with 150 μgm. of sodium L-thyroxine pentahydrate per 100 gm. body weight. All animals were killed two days following the injection of thyroxine, and the coenzyme *A* concentration determined in the various tissues by the Kaplan–Lipmann[5] procedure. (The coenzyme standard was supplied by Dr. F. Lipmann.)

The results are presented as per cent increase of the coenzyme *A* level in the treated group over that found in the control thyroidectomized group.

Coenzyme *A* Units per Gm. Fresh Tissue

	Liver	Heart	Brain	Intestine
Group *A*	49	18	9	7
Group *B*	121	25	12	10
Per cent increase of treated group	147	39	33	43

These results suggest that further studies of a more detailed nature into the relationship of coenzyme *A* and thyroxine should be made. If it is true that thyroxine acts by influencing the concentration of this coenzyme in tissues, a significant step will have been made towards understanding the action of thyroxine. In a collateral study it has been demonstrated that triiodothyronine in doses 1/5 those of thyroxine used above had substantially the same effect upon coenzyme *A* tissue levels[6].

A more detailed report of this work will be published elsewhere.

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Synthesis of Components of the Vitamin B Group by *Corynebacterium diphtheriæ*

In the course of a more extensive study concerning the metabolism of *C. diphtheriæ*, it was found necessary to estimate to what extent vitamins of the B group, known to function as co-enzymes for various desmolases, appear in the medium during the growth of the bacterium. Previously, the occurrence of pantothenic acid, thiamine and riboflavine in the culture filtrates of the diphtheria bacterium, grown on semi-synthetic media, has been strongly indicated[1]. On examining this further, the following additional vitamins (or substances with similar activity in microbiological assays) were found to be synthetized by *C. diphtheriæ*: vitamin B_6 complex, biotin, *p*-aminobenzoic acid, folic acid and vitamin B_{12}.

The assays were made from the routine medium and culture filtrate (crude toxin) used for the production of diphtheria prophylactic in this laboratory. This substrate is a modification of the low-nitrogen casein hydrolysate medium proposed by Holt[2]. It has a very low initial content of growth factors, except those included in the added essential nutrients of Mueller[3] (β-alanine, nicotinic acid, pimelic acid, cystine and the inorganic elements). The sodium chloride content of the medium is 0·5 per cent, and the nitrogen content is brought to 0·11 per cent by adding glycine and glutamic acid (1 : 1). Instead of the usual ferrous sulphate solution for the adjustment of the iron-level of the medium, a solution of yeast autolysate is used as a source of iron[4]. The yeast autolysate obviously contains, besides iron, some additional important factors, and thus a more regular and higher toxin production is guaranteed (usually 120–150 *Lf* doses per ml. in cultures incubated for five days at 34° C.—the initial purity of the toxin being greater than 1,000 *Lf* doses per mgm. protein nitrogen). One of the effective agents in the autolysate seems in all probability to be thiamine[5]; another is possibly inositol. The amount of yeast autolysate added to the medium is so small

Compound assayed		Found in: Medium	Found in: Culture filtrate	Assay organism and method
Thiamine	(γ/ml.)	++	+	*Phycomyces blakesleeanus* 21156. Technique ref. 7
Riboflavine	(γ/ml.)	0·12–0·13	14·0–17·3	*Lactobacillus fermenti* ATCC 9338. Technique ref. 8
Nicotinic acid	(γ/ml.)	3·4–3·6	1·6–2·1	*Lactobacillus casei e* ATCC 7469. Technique ref. 9
Pantothenic acid	(γ/ml.)	—	0·3–0·4	*Lactobacillus arabinosus* ATCC 8014. Technique ref. 9
Vitamin B_6 complex	(γ/ml.)	±	0·2–0·3	*Lactobacillus arabinosus* ATCC 8014. Technique ref. 7
Biotin	(mγ/ml.)	0·10–0·12	1·2–1·5	*Sarcharomyces carlsbergensis* 4228. Technique ref. 10
Inositol	(γ/ml.)	11·0–12·0	—	*Lactobacillus arabinosus* ATCC 8014. Technique ref. 7
p-Amino benzoic acid	(γ/ml.)	—	0·9–1·4	*Neurospora crassa* 37401. Technique ref. 11
Folic acid	(γ/ml.)	—	0·12–0·16	*Acetobacter suboxydans* 621. Technique ref. 7
Vitamin B_{12}†	(mγ/ml.)	±	7·0–11·0	*Streptococcus faecalis* ATCC 8043. Technique ref. 9
				Escherichia coli ATCC 9637, mutant 113-3*. Technique ref. 12.
				Lactobacillus leichmannii ATCC 4707. Technique ref. 9

* Obtained through the courtesy of Dr. Paul R. Burkholder, Yale University, Connecticut.
† Another 'Toronto'-variant of *C. diphtheriæ* producing an anomalous toxin on a medium with very high yeast autolysate content (ref. 13) was found capable of synthetizing more than 50 mγ/ml. of vitamin B_{12} in the culture filtrate.

that only riboflavine, biotin, inositol, thiamine and, of course, nicotinic acid can be detected in it in significant amounts. The strain of *C. diphtheriæ* used in this investigation was a 'Toronto'-variant labelled *CN* 2000, which was obtained from the Wellcome Research Laboratories, Beckenham, England, through the courtesy of Dr. F. V. Linggood.

In the analysis of the medium and the culture filtrate, the techniques used were exclusively those of microbiological vitamin assay. In the case of vitamin B_{12}, the identity of the active compound with vitamin B_{12} was ascertained paper-chromatographically[6]. The results are given in the accompanying table.

The figures given are extreme values from several assays from different batches of the medium and toxin (culture filtrate). The symbols ±, + and ++ are used when the activity of the tested compound in the sample was too slight to be estimated with sufficient accuracy, even when undiluted medium or toxin was assayed. In the case of thiamine it was, however, possible to observe that the toxin always had a clearly weaker thiamine activity than the corresponding medium. Thus it seems evident that this strain of *C. diphtheriæ* does not secrete thiamine into the growth medium. If thiamine is synthetized, it is retained in the bacterial cell.

Of the other compounds investigated, nicotinic acid and inositol are largely drawn from the substrate, inositol almost quantitatively. Riboflavine, pantothenic acid, vitamin B_6 complex, biotin, *p*-aminobenzoic acid, folic acid and vitamin B_{12} are synthetized and appear in the toxin in considerable amounts.

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Some Interrelationships of the Erythrocytes of Various Species with Plant Agglutinins

Early studies by Landsteiner[1] indicated that while plant agglutinins acted upon the red cells of most species, specificity could be considered to exist if the action of a given plant extract against a limited series of cells was considered. For example, lentil extracts agglutinated rabbit's red cells but not pigeon's red cells. Recent experiments[2] revealed that extracts of common strains of *Dolichos biflorus* agglutinated human *A* cells quickly and sheep's cells after 5 min., but not human cells of groups *B* and *O*, or those of some other species.

The fact that the cells of some species are agglutinated by extracts which fail to agglutinate the cells of other species indicates that the former possess certain red-cell receptors which are lacking in the latter. It was therefore considered instructive to determine the reactions of several plant extracts upon the red cells of many species. The antigenic composition of the various bloods in relation to the numerous plant antibodies might thus be established; and if differences are found to exist, a simple means of identification of these bloods might become available. Accordingly, in a preliminary experiment, extracts of *Ricinis communis*, *Dolichos lablab*, *Vicia faba* and *Phaseolus lunatus* were each put up against cell suspensions obtained from the bloods of the following species: sheep, goat, water buffalo, cow, horse, dog, chicken, pigeon, rabbit, guinea pig, and man (groups *A*, *B* and *O*).

The extracts were prepared by the simple mortar-and-pestle method of Boyd and Reguera[3]. 2 per cent suspensions of fresh unwashed cells of the various species were tested against each extract by the tile method, as in simple human blood-grouping, and the results read macroscopically within ten minutes. Negative results were checked under the microscope.

Agglutination Reactions of Various Erythrocytes with Certain Plant Agglutinins

	Ricinis communis	*Dolichos lablab*	*Vicia faba*	*Phaseolus lunatus*
Sheep	+	−	−	−
Goat	+	−	−	−
Buffalo	+	−	−	−
Cow	+	−	−	−
Horse	+	−	−	−
Dog	+	−	−	−
Chicken	+	+	−	−
Pigeon	+	+	−	−
Rabbit	+	+	+	−
Guinea pig	+	+	+	−
Man (group *B*)	+	+	+	−
Man (group *O*)	+	+	+	−
Man (group *A*)	+	+	+	+

It quickly became evident that there are differences in the erythrocyte antigen pattern of various species (see table). So far the following different groups can be recognized, the members of which are apparently indistinguishable from one another :

Sheep—goat—buffalo—cow—horse—dog.
Chicken—pigeon.
Rabbit—guinea pig—man (groups *B* and *O*).
Man (group *A*).

Testing at a higher level, by using a wider range of plant extracts, might enable a more complete differentiation of various bloods to be made. For example, soya bean extracts are said to agglutinate rabbit's red cells[4] but not human red cells[3].

The experiments described do not take into consideration the likelihood that differences, *vis à vis* plant antibodies, might exist among individual members of each of the species tested. This aspect will have to be fully examined before any firm conclusions can be established. The possibility of differences occurring in the activity of varieties or strains of each of the plants used must also be considered. Minor differences may also arise if a more delicate technique is employed.

It is felt, however, that the differences so far noted are sufficiently striking to merit publication at this stage. Further investigation might be of zoological, botanical, and possibly forensic interest.

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A Precursor of Methoxy-para-benzoquinone in Wheat Germ

In September 1952 a preliminary communication was read at the Second International Congress for Fermentation Industries held at Ostend, in which we demonstrated the formation of methoxy-*para*-benzoquinone from an aqueous germ extract. The method used differs from that of Vuataz[1] and of Cosgrove *et al.*[2] in that we did not use any yeast but treated our germ extract with potassium iodate in acid medium. From this we concluded that the germ extract contains the precursor of methoxy-*para*-benzoquinone, and we mentioned the isolation of this precursor (*X*).

Isolation was accomplished in the following way. An aqueous extract of fat-free germ was boiled and treated with 75 per cent alcohol to remove part of the proteins. The rest was concentrated *in vacuo* and extracted with acetone. This was in turn distilled off *in vacuo* and the rest dissolved several times in absolute alcohol, treated with increasing concentrations of benzene up to three times its volume and passed through a column of aluminium oxide. Elution with 85 per cent acetone gave a concentrated solution of *X*. Purification resulted in a white crystalline powder melting at 202°. A very sensitive reaction for *X* is the formation of methoxy-*para*-benzoquinone mentioned above, that is, the addition of iodate in acid medium and demonstration of the benzoquinone with aniline (red colour). By chromatographic methods the hydrolysate of *X* was shown to contain glucose and methoxyhydroquinone (MHQ). From this fact and a number of other reactions, we concluded that the *X* substance was in all probability a monoglucoside of methoxyhydroquinone.

We have now succeeded in synthesizing this product in the following way :

$$\text{Vanillin} \xrightarrow{H_2O_2} \text{MHQ} \xrightarrow[Ba(OH)_2]{\text{Penta acetylglucose}} \text{tetra-acetate of the glucoside of MHQ} \longrightarrow \text{glucoside of MHQ.}$$

This substance, melting at 202° C., did not give any depression of melting point when mixed with the natural product obtained from germ. Moreover, it gave the same reaction with : (1) iodate in *p*H 3·7 buffer with aniline ; (2) the Ehrlich diazo-reagents ; and (3) the 2,6 dichloroquinone-chlor-imide. The light extinction curves were identical and gave maxima for (1) at 5150 and for (3) at 6000 A. As toluene sulphonic acid was used as a condensation catalyst in the reaction with penta-acetyl-glucose, the formation of a β-glucoside structure is highly probable. The only thing not definitely settled in the structure of *X* is the place of the glucoside binding. This can be either *ortho* or *meta* to the OCH_3-radical. In an analogous way, the glucoside of the dimethoxy hydroquinone (*XX*) was synthesized.

Neither *X* nor *XX* show any improving action on wheat dough. This is in contrast with our earlier investigations on the improving action of quinones[3,4].

In analogy to the work of Neuberg[5] on the glucosidase activity of yeast on arbutine (a glucoside of hydroquinone) we found that even in synthetic nutrient medium the glucoside linkage of *X* was ruptured by yeast. By chromatographic methods the presence of methoxyhydroquinone and glucose could be demonstrated. There are a few conditions necessary to demonstrate the formation of methoxyhydroquinone, namely, absence of sugar in the medium as well as the absence of air and peroxidative enzymes. In the presence of oxygen and still more quickly in the presence of a peroxidative enzyme and oxygen, methoxyhydroquinone will be oxidized to methoxy-*para*-benzoquinone, as can easily be demonstrated by the aniline reaction without iodate.

An emulsion of almonds can also split *X*, and in all probability all leaves containing analogous glucoside compounds have a glucosidase capable of splitting *X*. The presence of a glucosidase in the germ fraction from the mill can also be proved. This must be ascribed to parts of the endosperm.

The slight red tinge of a germ dough after standing longer, or better still after longer contact with yeast, is an indication of the formation of methoxy-*para*-benzoquinone. The presence of the glucosidase action in germ (the formation of methoxyhydroquinone from *X*) can be demonstrated in aqueous enzyme extracts by working in oxygen-free media or in media of a slightly reducing nature. By the decrease in *X* with time as well as by spot reactions on filter paper with the Ehrlich diazo reagent in ammonia vapour or by the reduction of 2,6 dichlorphenol indophenol, the formation of methoxyhydroquinone from *X* can be followed. In the presence of air the methoxyhydroquinone (MHQ) is oxidized to methoxy-*para*-benzoquinone (MPQ), which in its turn is partially coupled with an unknown substance to produce a red-brown colour.

Consequently, the following reaction of *X* is as shown:

$$X \xrightarrow{\text{glucosidase}} \text{MHQ} \xrightarrow[\text{with or without peroxidase}]{\text{oxidation}} \text{MPQ}$$

MPQ → (1) irreversible binding of SH-amino-acids.
MPQ → (2) reversible oxidation of SH to S—S.
MPQ → (3) deamination to aldehydes.

Reaction (1) is only possible if hydrogen atoms are available at two adjacent carbon atoms of the benzene nucleus. Moreover, the demonstration of such an enzyme system is of importance for dealing with the problem of the physiological function of *X*. The general opinion is that such glucosides are formed for storing poisonous substances (in this case methoxy-hydroquinone) in physiologically inactive form, formed as a by-product of one of the processes of plant metabolism. An alternative is that this *X* substance—while in itself physiologically inactive—can act (after enzymatic decomposition) as a physiological agent or regulator of some process occurring during certain stages in plant-life. Both methoxy-hydroquinone and its oxidation product methoxy-*para*-benzoquinone are substances with marked physiological activity. It will probably depend on the stage of plant-life which of these two possibilities, that is, formation or hydrolysis of *X*, will occur.

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Thyroid Hypofunction and the Development of the Central Nervous System

Methyl thiouracil depresses the thyroid, and the brains of rats made cretinous with this drug grow proportionately less in length than they do in width or height[1]. Further results of this treatment are that myelination is retarded[2] and that the pyramidal cells of the lamina ganglionaris of the sensori-motor cortex are smaller and more closely packed than in normal animals[1]. The spaces between the cell bodies are occupied for the most part by neuroglia, blood vessels, axons and dendrites, and an attempt to find an explanation for the closer aggregation of the cell bodies in cretins has been made by analysing the rate of growth of each of these components.

It has been found that the volume of glial tissue in the cretinous rats was increased rather than decreased in relation to the normal, so that a change in the amount of supporting tissues does not account for the reduced intercellular spacing characteristic of the cerebral cortex of the cretin. It has also been found that the volume of cortical tissue occupied by blood vessels was slightly, though not significantly, increased in the brain of the cretins. Decreased vascularity cannot, therefore, be the explanation of the closer packing of the neurones. There was, however, a significant difference between cretins and normal animals in the size and distribution of the vessels. In general, the number of vessels 5 μ in diameter or smaller (capillaries) was less in the tissues of the cretinous than of the normal rats, while the number of large vessels (exceeding 5 μ in diameter) was significantly greater. The difference was most marked in those cortical lamina (3, 4 and 5) which are normally the most vascular. Furthermore, there was a general increase in the mean size of the blood vessels in the tissues from the cretins, notably of the capillaries in all laminæ, and of the large vessels in those laminæ nearest the cortical surface.

Other significant differences emerged from a study of the axons and dendrites. The number of axons present in silver-impregnated sections proved to be significantly fewer in the sensori-motor cortex of the cretinous than of the normal rats. Furthermore, although the mean number of dendrites arising from the pyramidal cells in layer 5 (Golgi–Cox preparations) was slightly greater in the cretins than in normal animals, these processes branched less frequently and were significantly shorter. The dendritic fields associated with the pyramidal cells were thus less dense in the brain of the cretin than in the normal. It seems, therefore, that the closer packing of pyramidal cell bodies in the tissues of cretinous rats can be attributed to a deficiency in the growth of neuropil as well as to a retardation in myelination.

The development of the neuropil is generally thought to be a highly significant index of the functional maturation of the cerebral cortex[3,4], and a disturbance in this respect, superimposed upon the disorders of metabolism normally associated with hypothyroidism, may therefore be regarded as contributing largely to the abnormalities of behaviour associated with cretinism.

There is at present little evidence to show whether the changes reported here are the direct effects of thyroid deficiency on nervous tissues or whether they are secondary disturbances. In this connexion, the fact that the brain of the cretin is distorted in shape is probably significant. This abnormality differs only in degree from that which follows hypophysectomy during infancy[5], a condition which has been attributed to a disproportionate growth of the brain and endocranium resulting from a failure of endochondral growth at the basi-sphenoid/pre-sphenoid and spheno-occipital synchondroses. Such incompatability in growth relationships would tend to increase intracranial pressure, which, by restricting the venous drainage from the brain, might be expected to lead to an engorgement of the capillary bed and post-capillary drainage channels in a manner consistent with the experimental observations reported above. Conditions of this kind would inevitably lead to stagnant anoxia, which is known to cause severe damage to developing nervous tissues[6].

Medication of cretinous rats with thyroxin results in a rapid restoration of somatic growth, and so presumably of normal cranio-neural relationships. Preliminary studies have shown that the recovery is associated with at least a partial restoration of normal behaviour, for animals in which the appearance of automatic reflex responses had been grossly retarded during infancy have, after subsequent treatment with thyroxin, learned to run an elevated T-maze at least as well as normal, and better than untreated, littermates[7]. This finding is unexpected in the light of the widely accepted view that the cerebral changes associated with thyroid deficiency in man are irreversible if therapy is unduly delayed[8]. A possible explanation of this discrepancy is that the maze used was inadequate as a test of higher cortical function, for medicated cretins have so far failed to perform

delayed response tests within the capacity of normal rats. On the other hand, the irreversible cerebral changes in many human cretins may be due not so much to thyroid deficiency as to the coincidence of some other congenital defect[9]. A more detailed experimental study of the effect of replacement therapy in the cretinous rat should reveal the relative importance of genetic and endocrine influence on cerebral maturation.

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Formation of Neurofibrils in the Brain of a Human Fœtus 28 Weeks Old

Frozen sections of formalin-fixed tissue of a human fœtus 28 weeks old were impregnated with silver, using Bielschowsky's technique to show neurofibrils, and stained by other methods. Detailed histological findings will be published later.

Very fine and coarser fibrils were numerous in the deepest one-third of the cerebral cortex bordering the central fissure; elsewhere in the cerebral cortex there were a few coarse fibrils. Fine and coarser fibrils were present also in the cerebral white matter and in subcortical centres. Where the production of fine fibrils had occurred in the cortex, nuclei were relatively large, widely spaced and possessed a more mature nucleolar structure than was seen elsewhere in the cortex (Fig. 1). Except in occasional instances deep in the postcentral cortex, perinuclear cytoplasm was not seen either in silver preparations or after staining with azur *A* at *p*H 4. The globus pallidus also contained numerous fine fibrils, lying outside nerve cells in the cytoplasm of which neither Nissl substance nor neurofibrils were demonstrable (Fig. 2). The latter structures, although not Nissl substance, were seen in the same preparation within occasional nerve cells in the external reticular nucleus of the thalamus. There was no demonstrable continuity between intra- and extracytoplasmic fibrils.

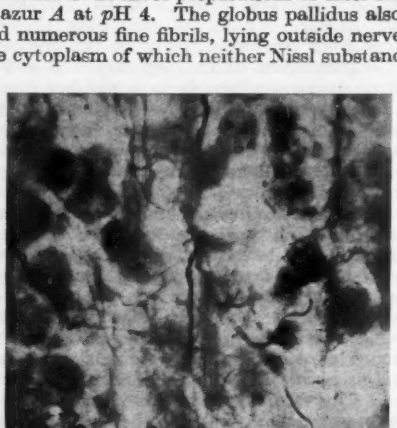

Fig. 1. Cerebral cortex treated by Bielschowsky neurofibril method. (× 1,000)

Fig. 2. Globus pallidus, same method. (× 1000)

Extracytoplasmic fibrils were thus already present in large numbers. Centres from which afferent fibres might have originated (to cortex, lateral part of thalamus; to globus pallidus, putamen and thalamus) were, on the other hand, markedly immature. For these reasons the possibility of more than a very few of the observed extracytoplasmic fibrils being axonal terminals could not be entertained.

The histological differentiation of neurones is thought to correspond to the onset of nucleoprotein synthesis by the maturing cells[1]. Fibrillogenesis in the central nervous system may therefore be the precipitation of a fibrous protein within an intercellular substance such as exists in membranous connective tissue[2], elaborated in this instance by developing nerve cells. Ultra-microscopic appearances suggest the presence of a similar ground substance in the adult mouse cerebral cortex[3].

The fibres which have been described probably serve as a framework for subsequent neuronal development in the growing brain. Chemical changes attending their production are not known. A study of the metabolic aspects of their origin might form a link between observed histological phenomena and protein synthesis.

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Neurohæmal Organs in Crustaceans

A number of structures of nervous origin in the higher Crustacea have recently been described under a variety of names, although they show a unity of structure and possibly of function. We wish to propose, tentatively, a common name to denote organs of this type in crustaceans, in order to avoid a needless multiplicity of names for organs which have many features in common. The organs are: the sinus gland of the eyestalk[1,2]; part of the pars

distalis of the *X*-organ of the eyestalk[3,4]; the sinus plate or post-commissural organ of the tritocerebral region[5]; the pericardial organs of decapods[6]; the dorsal lamellæ of the pericardium of *Squilla* and the associated system of dorsal trunks[7]; the transverse bar in the ventral blood sinus of the sixth thoracic segment of *Squilla* and the associated system of median connectives[8]; the apparatus nervi dorsalis cordis of the crayfish[9]; the neuropiles, or punctate substance, which extend over the ligaments of the heart in *Palinurus* and *Scyllarus*[10].

Each of these structures consists of the endings of nerve fibres, located in or alongside the walls of blood vessels or blood cavities, or even in the blood itself. The authorities cited in the list above are not always those who first described the organ concerned but who showed that it had this nature. The nerves running to these organs, are, apparently always, efferent, but do not supply any muscle; the organ to which they run is formed mainly from their own endings. The first five listed have been shown to contain hormonal material[1,2,5,11]; the function of the others is unknown; it may be that they, too, are endocrine organs.

It seems preferable to call these organs by some purely topographical name which does not denote any function, actual or supposed. The adjective 'neurohæmal' seems to us to be the most appropriate topographical name denoting the common feature of these organs. The organs may thus be referred to collectively as neurohæmal organs, while the adjective may be combined with any of the pre-existing names for these various organs, as, for example, 'the post-commissural neurohæmal organ' and 'dorsal neurohæmal lamella'.

The neurohæmal organs of the higher Crustacea are of two chief kinds. The first type Alexandrowicz has referred to as 'neuropiles', in which the organ is made up of fine, ramifying nerve-endings, between or along which are found numerous small droplets. The post-commissural neurohæmal organ, the transverse neurohæmal bar, the dorsal neurohæmal lamellæ, the pericardial neurohæmal organs and the neurohæmal organs of the heart ligaments are all neurohæmal neuropiles. Certain authorities in conversation have objected to the use of the term 'neuropile' in this context on the grounds that it was coined to describe areas in the central nervous system. It is true that the term was first used in this way; but standard definitions of the word, such as that of Hanström[12], give it a purely descriptive significance with no topographical connotations. We may distinguish between the well-known central neuropiles and these less-known peripheral neurohæmal neuropiles which, however, still come within the definition of the term 'neuropile'. The second type of neurohæmal organ is believed to be made up of enlarged nerve-endings. The sinus gland, the neurohæmal portion of the *X*-organ and the apparatus nervi dorsalis are neurohæmal organs of this second type.

We feel that the term neurosecretory organ or system should be reserved for the entire complex, comprising nerve cell bodies, nerve fibres and neurohæmal organ, which produces, transports and releases the neurosecretion; it should not be confined to or used for a neurohæmal organ by itself. Under this terminology, the complex pars ganglionaris *X* organi, sinus gland tract and sinus gland form a neurosecretory system, and sinus gland itself is a neurohæmal organ.

A neurohæmal organ is therefore defined as a crustacean organ composed of a group of nerve-endings bearing close spatial relationship to the blood-vascular system.

This proposed nomenclature has been discussed at the recent symposium on neurosecretion held at the Zoological Station, Naples, during May this year, and received general support.

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A New Method for determining the Transition Temperature of Insect Cuticular Waxes

Beament[1–3] has described three methods for determining the transition temperature of insect cuticular waxes. For studying the influence of culture temperature on the transition point of the waterproofing wax in insect eggs, however, none of these methods is suitable, since either (*a*) the determinations are made on batches of several eggs, so that individual variation is obscured, or (*b*) the end-point is not sharply defined.

Preliminary experiments have now been carried out, using an electrical method which it is believed is capable of giving results accurate to $\pm 0{\cdot}1°$ C. The material used was three-day old eggs of *Rhodnius prolixus*, which have a waterproofing wax layer inside the chorion; but the method is readily adaptable to other types of material.

A fine capillary filled with $M/10$ potassium chloride solution is sealed into the egg. A non-polarizing electrode leads from this capillary, and another non-polarizing electrode from the vessel of $M/10$ potassium chloride solution in which the egg is immersed. The vessel is heated slowly by suspending it in a water-bath, while an externally applied potential difference is maintained between the two electrodes; the current flowing across the egg membranes is noted as the temperature rises.

Over a range of 2 deg. C. on either side of the transition temperature, the curve of current/temperature obtained is similar to the permeability/temperature curves obtained by Beament[2], suggesting that in this connexion current (which is proportional to ionic permeability) may be used as an indication of the water permeability at a given temperature. The transition temperature may be defined as the point on the curve where d^2i/dT^2 is maximal, at which point it is considered that the greater part of the components of the wax layer passes through the transition.

Values of the mean transition temperature for a number of eggs from each of three cultures agree broadly with those obtained by Beament.

Material. Eggs from :	Mean transition temperature (° C.)
(*a*) ♀♀ kept for 3 weeks at 23° C.	41·64 ± 0·13
(*b*) ♀♀ cultured at 28° C.	42·28 ± 0·20
(*c*) ♀♀ kept for 8 days at 32·5° C.	42·43 ± 0·12

The differences between the mean transition temperatures are statistically significant at 0·01 per cent.

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Radioautographic Study of the Localization of Tobacco Mosaic Virus Antigen

The localization in animal tissues of injected antigens has been, during recent years, the object of a great number of investigations in order to identify the cells responsible for antibody production. This problem is related to the more general one of the localization and mechanism of protein synthesis.

An important contribution to these studies has come from the use of chemically[1,2] and isotopically labelled antigens. Antigenic iodoproteins labelled with iodine-131 have been used in most cases[3] and their localization in liver mitochondria has been established by Haurowitz and Crampton[4,5]. Libby and Madison[6] have, on the other hand, used as antigens tobacco mosaic virus labelled with phosphorus-32 and found that they were localized chiefly in the liver, but also in the spleen; this reaction is related to the production of antibodies. However, these investigations have not definitely clarified the nature of the specific cell-types responsible for antibody production: some authors[7] emphasize the role of the reticulo-endothelial tissue (young reticular elements, histiocytes, plasma cells, macrophages); but others believe in the major contribution of lymphoid cells[8,9].

The method used for our investigations was as follows. Radioactive tobacco mosaic virus was crystallized from infected leaves grown in an atmosphere of carbon-14 dioxide; a concentrated solution (± 10 mgm. containing 32·000 c/m.) was injected intravenously into mice. Blood was collected at different intervals and, in the case reported here, the mouse was killed on the fourth day after the injection. The tissues were fixed in acetic alcohol, embedded and sectioned at 6 μ. Blood and bone marrow smears were fixed with methanol. Both the histological slices and the smears were covered with photographic emulsion 'in gel form' (G_5 Ilford) 40 μ thick, when dried.

This method makes it possible to localize individual beta-ray tracks coming from the carbon-14. After 2–6 days exposure, the slides were developed in amidol-sulphite at *p*H 7–8 and fixed in 30 per cent saturated hyposulphite. Histological sections were stained with methyl green–pyronin, and the smears with Giemsa solution. It was found that a preliminary treatment in 75 per cent ethanol increases considerably the diffusion of the dyes through the emulsion.

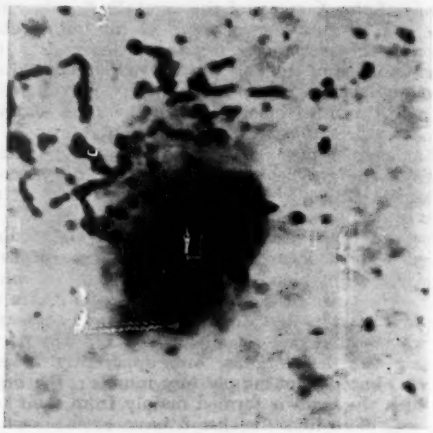

Fig. 1. Plasmoblast in the bone marrow with numerous tracks emitted by the cytoplasm only

The following experimental results were obtained.

Blood. Beta-ray tracks were counted in smears prepared at different times after injection; radioactivity of the cells fell to 50 per cent of the initial value after 3 hours, and afterwards this drop was much slower. After 48 hours, one-third of the initial activity was still found. This pattern was confirmed by direct counts in a Geiger–Müller counter. No tracks were observed in either red or white blood cells; apparently virus remains in solution without being incorporated in the corpuscles.

Bone marrow. Cells of the granulocytic or erythrocytic lines do not contain any activity. On the contrary, the reticular cells (young reticular elements, histiocytes, plasma cells) are highly radioactive. The beta-ray tracks are of cytoplasmic origin (Figs. 1 and 2). Observation of the other tissues demonstrated that spleen had the highest activity; liver was also very active. Conversely, incorporation was much less in the lymph nodes, kidney and lungs, and scarcely detectable in muscle.

Spleen. Cells of the red pulp and of the venous endothelium fixed a considerable amount of antigen.

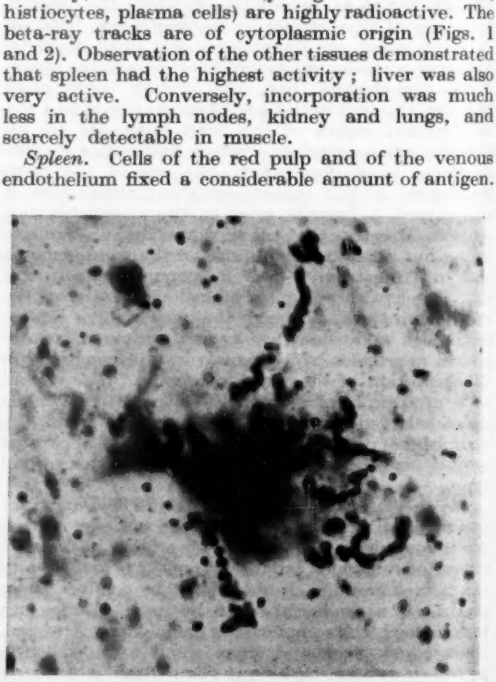

Fig. 2. Young reticular cell of bone marrow with β-ray tracks coming out of cytoplasm

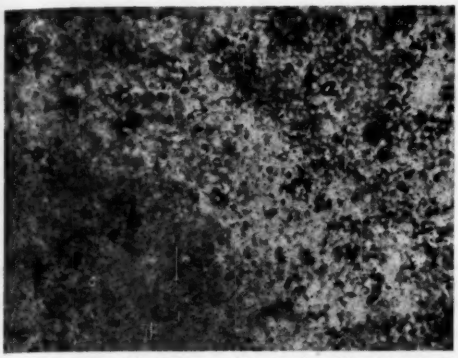

Fig. 3. Region of the spleen: (*a*) red pulp; (*b*) quadrant of a lymphocyte follicle (white pulp); (*c*) central area of the follicle

Young reticular elements having a highly basophilic cytoplasm were found to be the most active. The radioactivity of the lymphoid follicles was only slightly above that of the background. However, in the centre of the follicle, where younger and larger cells were found, there was a measurable incorporation (Fig. 3).

Liver. Numerous beta-ray tracks were found in the Kuppfer cells, and also in the hepatic cells, most of which were proximate to the portal spaces. Here also, most tracks originated from the cytoplasm; however, some rare nuclei appeared to emit electrons.

Lymph nodes. Radioactivity was considerably less than in the spleen and liver and chiefly localized in the endothelial cells of the sinuses.

Kidney. Although the kidney was found to be slightly radioactive, it has not been possible to determine if this activity crossed the glomerular barrier.

Lung. This was also found to contain weak activity, mainly localized in the connective and vascular tissue.

In conclusion, these observations allow us to conclude that the tobacco mosaic virus injected intravenously as an antigen is chiefly concentrated, after four days, in the spleen which is enlarged. The young and highly basophilic elements of reticular origin, which are considerably increased in number, seem to play a predominant part in the early steps of the antigenic reaction.

We are greatly indebted to Prof. R. Jeener for the preparation of labelled tobacco mosaic virus.

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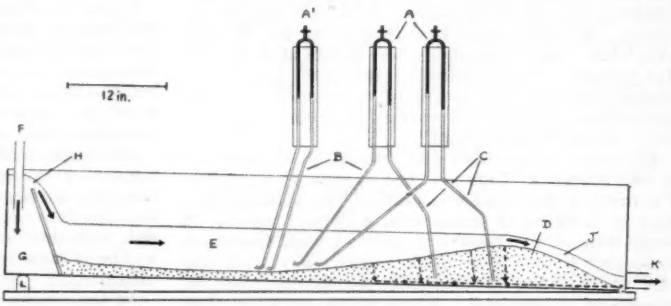
Water Currents through Permeable Gravels and their Significance to Spawning Salmonids, etc.

Field observations using soluble dyestuffs introduced in crystalline form have demonstrated the existence of a well-defined flow of water beneath the river-bed at such sites as are chosen for the redd by spawning salmon and trout. Situations where the gravel is consolidated beneath the surface are avoided. These observations have considerable interest both as regards 'selection' of spawning sites calculated to afford adequate aeration for ova and alevins and, in a wider context, in the ecology of various invertebrates or their larvæ[1].

It has been found possible to demonstrate the relative values of these currents in a model pool by means of a series of manometers arranged in a specially designed tank (see accompanying diagram).

Manometers, based on the well-known Pitot apparatus for measuring current velocities, are set up so that one limb of each manometer penetrates the gravel bank. The height of the contained water column thus depends on the downward-flowing current in the gravel. The other limb of each manometer rests in the relatively static water in the middle of the pool. A control manometer (*A'*) with two 'static' limbs is also set in position. An indication of the relative strength of the currents at various points in the pool is obtained by comparison of the heights of the water columns in each manometer. The readings obtained



Diagrammatic section through model pool.

A, Manometers showing height of water columns; *A'*, control manometer; *B*, static limbs; *C*, limbs inserted in gravel; *D*, gravel bank; *E*, pool; *F*, inflow from mains; *G*, surge chamber; *H*, overflow to pool; *J*, overspill; *K*, outflow from tank; *L*, movable block for adjusting gradient. The broken lines in the gravel bank indicate the paths of the current

from these manometers show that the currents through the gravel are remarkably consistent and the water columns are not subject to the rapid fluctuations associated with the Pitot tube used in the normal fashion. The apparatus has been found to be equally effective in a natural pool, and its use in the field seems likely to provide an accurate assessment of natural spawning facilities.

It can be shown that these currents are dependent chiefly on the gradient from one pool to the next and not on the velocity of the stream. The manometer readings indicate clearly that the strongest current through the permeable gravel occurs below the apex of the gravel mound and that the currents decrease in strength towards the middle of the pool, where they cease.

The model has demonstrated further that these currents are more positive than had been hitherto

realized and also, by the use of dyes and other materials, that their direction downwards through the gravel is approximately at right angles to its surface, irrespective of the gradient of the gravel bank.

The influence of these currents on the distribution of the bottom fauna and flora is being investigated, but it is evident that incubating ova and developing larvæ of salmon, trout and minnows are thus provided with the maximum aeration possible.

Further indication of the biological significance of these currents has been obtained incidentally by the successful spawning of minnows (*Phoxinus phoxinus*, L.) in the experimental tank, no previous record of which is known to me. The ova deposited at the surface of the gravel became lodged in the gravel bank, presumably by the action of the downward currents, and some thousand fry have since been reared in this tank. A full account of this work will be published elsewhere.

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Frequency of Moulting in Anura

There appears to be no accurate information available on the frequency with which the Anura moult. In his recent monograph on the British Amphibia, Smith[1], discussing the habits of *Bufo bufo* (L.), writes: "Periodically the skin is shed, certainly several times in the course of a summer. Gadow states that they shed it every few weeks, but this surely is an overstatement".

We have investigated the frequency of moulting in two species of *Bufo* and one species of *Breviceps*. The method employed was simple. The animals were kept in isolation in boxes with a dish of water. A small area of the back was painted with Gestetner correcting fluid. This mark comes away with the cast at the time of moulting, which can thus be accurately determined. There is no evidence that the fluid has any adverse effect upon the animals. Observations were made every twelve hours and the animals were maintained at a constant temperature of 20° C. The results obtained are summarized in the accompanying table.

	Bufo regularis Reuss	*Bufo carens* Smith	*Breviceps mossambicus* Peters
Mean duration of intermoult (days)	5·8 ± 0·1	4·3 ± 0·1	5·7 ± 0·2
Maximum and minimum values (days)	3·5–9·5	3·0–6·5	4·0–6·5
No. of animals	80	16	4
No. of observations on each animal	6	5	5

It will be seen that the moulting of these three species is a much more frequent event than had hitherto been suspected. Preliminary observations on *Rana oxyrhyncha* Smith, *Rana umbraculata* Bush and *Xenopus lævis* Dandin indicate that these largely aquatic species moult about once a week; but no satisfactory method of marking has yet been developed which allows accurate quantitative statements to be made.

A fuller account of these results, together with observations on the influence of environmental and other factors on moulting, will be published elsewhere.

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Use of X-Ray Stereoscopy for examining Shipworm Infestation *in vivo*

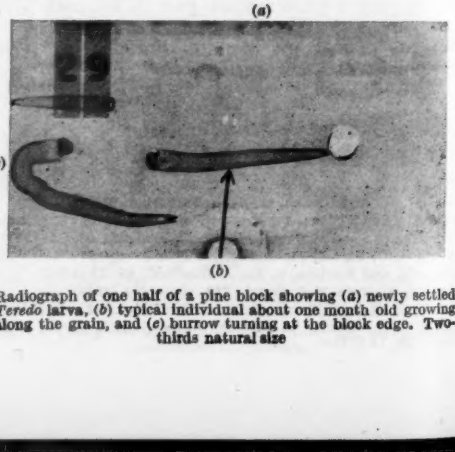
The ravages of the shipworm, *Teredo* sp., particularly in warmer seas, are notorious. In order to combat these attacks several methods of control are in use. The pretreatment of timber by creosote, preferably under pressure, is normally recommended, though other compounds have also been employed.

Prerequisites to the development of improved treatments are: (*a*) a knowledge of the habits of the larval *Teredo*, its method of entry and selection of points of attack; (*b*) the growth and behaviour of the adult; (*c*) a reliable method of assessing attack by *Teredo* on experimentally treated wood blocks.

Since the *Teredo* enter the wood as minute larvæ, and remain inside, they are scarcely noticed until the block falls to pieces as a result of their activity. Assessment or examination of the extent of attack before this occurs normally involves opening up the wood, as, for example, by planing off the surface[1]. This inevitably terminates the experiment.

Although as early as 1924 a photograph of heavily infested wood taken by means of X-rays was published by the National Research Council, Washington[2], the idea does not appear to have been put to practical use. It is therefore hoped that the details given below will be of assistance to workers investigating measures of control.

In the course of work carried out during the past three years on the efficacy of various methods of treatment of experimental wood blocks we have used X-rays for *in vivo* examination of *Teredo* without causing them or the blocks any injury. This has allowed us to follow the growth and boring habits of individual shipworms from the time of their initial settlement in the wood.



Radiograph of one half of a pine block showing (*a*) newly settled *Teredo* larva, (*b*) typical individual about one month old growing along the grain, and (*c*) burrow turning at the block edge. Two-thirds natural size

The method depends upon the opacity to X-rays of the two reduced valves or head plates at the anterior end of the animal, the posterior accessory pallets, and the calcareous lining which it secretes around its burrow in the wood. Since even the minute valves of the newly settled larvæ show up clearly (Fig. *a*) the actual onset of the attack is revealed immediately. Later radiographs show the extent of the infestation, the position of each animal and its tube being sharply defined against a background formed by the grain of the wood.

A low-power mobile X-ray set was chosen for this work as the tube had low inherent filtration and a 1-mm. focus, ample contrast and resolution being obtained on Ilfex film at 40 kVp., with an exposure of 10 mA./sec. at 30 in. focus-film distance. Using the same film, the work is possible with the smallest portable set obtainable. Infected blocks were scraped clean of surface growths and photographed in the laboratory, lead numerals serving to identify the blocks and to indicate a reference plane. The blocks were replaced in the sea within a few hours of removal for examination. In this way it has been possible not only to follow the whole course of attack in series of experiments on infected blocks, but also to obtain information on the times and preferred positions of settlement, on growth-rates, and growth habits.

With wooden blocks ½–1 in. in thickness it was found desirable to introduce stereoscopy in order to interpret the arrangement of the burrows. A degree of hyperstereoscopy was achieved by moving the stereofilm changer along a track parallel to one side of the film through a distance equal to one-sixth of the focus-film distance instead of the normal one-tenth. This gave an apparent 50 per cent increase in depth in a Wheatstone stereoscope; with greater hyperstereoscopy there was a risk that the conglomerate images of heavily infected wood might be difficult to dissociate. In some instances fiduciary wires were placed along the two sides of the picture space to indicate a surface plane and to measure shadow shifts if required.

Stereographs of heavy infestations taken by this means give a remarkable effect, the tubes being seen in three dimensions intertwined among each other, yet every tube quite isolated from its neighbours.

A paper giving further details of the use of this technique is in course of preparation and will be published shortly.

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Occurrence of *Phoronis mülleri* in the Irish Sea

The recent discovery of *Phoronis mülleri* de Selys Longchamps off the west coast of the Isle of Man appears to constitute the first British record of the adult of this species; according to de Selys Longchamps, the larva of *Phoronis mülleri* is *Actinotrocha branchiata* J. Müller, which he states has been found at Millport, St. Andrews, Plymouth and Valencia[1].

There have been no previous records of adults of any species of *Phoronis* in Manx waters; but larvæ, recorded as "*Actinotrocha* sp.", were found in Port Erin Bay from June to August 1899[2]. The discovery of the adult *Phoronis mülleri* was made during quantitative investigations of the offshore polychæte fauna in November 1952. It was found to be common in muddy sand at depths of 37–62 m., and to occur occasionally down to 74 m. in an area between four and seven miles west of the Niarbyl.

Phoronis mülleri was first described from Heligoland, where it was found in muddy sand at 35–37 m.[1]. It was next recorded from the west coast of Sweden, again from muddy sand, at all depths from 9½ to 53 m.[3]. The latest record of which I am aware is from Danish waters, where some post larvæ were found west of the Island of Ven in the Øresund, at a depth of 16 m.[4].

Unlike the two other British species (*Phoronis hippocrepia* Wright and *Phoronis ovalis* Wright), *Phoronis mülleri* is not colonial and does not bore into dead shells. It builds a tube of sand up to 80 mm. long by 1 mm. wide which stands vertically in the substratum. The species may be distinguished from all others of the genus by the shortness of the tentacles on the oral side of the lophophore[1, 3].

It appears that *Phoronis mülleri* is restricted to offshore grounds of muddy sand, and it is probable that it will be found to be more widely distributed than it is known to be at present.

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Fluorine Tests in Australia on the Keilor Skull and a Tertiary Marsupial

The Keilor Skull. The application of the fluorine-phosphate method described by Oakley and Hoskins[1] for determining the relative ages of fossils has shown that the Keilor Skull from near Melbourne is a true fossil, and its age that of the terrace in which it was found. The ratio $\frac{\%F \times 100}{\%P_2O_5}$ for the skull is 2·0, and of other fossils found *in situ* in the terrace 1·9, 1·5 and 2·9. Different parts of a rat skeleton gave 3·8 and 4·4—higher than anticipated, and due to low percentage of phosphate. I am indebted to Mr. W. R. Jewell, chief chemist, State Laboratories, Melbourne, and his staff for carrying out the analyses.

The various terraces at Keilor can now be recognized by their lithology, their spatial relationships

and their soils. There are remnants higher than those reported earlier[2]. The Keilor Terrace is not as old as originally estimated, for a prominent diastem in the Keilor Terrace runs also at the same height through the Braybrook Terrace. The two terraces have the same lithology and the same soil, so the Braybrook Terrace is but a partly eroded Keilor Terrace.

In addition to the evidence of the fluorine test, it is concluded that the Keilor Skull could not be a burial because even on present levels it would mean an excavation of 9 ft. from the surface of the terrace or 25 ft. from the bank of Dry Creek. Also one would expect to find much more than the skull if a comparatively recent intrusive burial had occurred. Deposition of the Keilor flood-plain has nothing to do with eustatic sea-levels, in my view, but was a function of restriction by the narrow winding gorge at the downstream end of the flood-plain in a time of higher rainfall. Since then, the river has cut down to bedrock, deposited the Maribyrnong Terrace, and the sediments of the Keilor Terrace (including the Braybrook Terrace) have been oxidized. In the lower part of the Maribyrnong River (from the banks of which the Keilor Skull came), deposits associated with eustatic changes of sea-level have been traced for more than eleven miles along the river, and the relationship of these to the terraces is under investigation.

An official police inquiry has shown that there was not a second skull as earlier reported[3]. The misunderstanding arose apparently from lack of knowledge of bones by the sand contractor who signed the statement. War-time conditions precluded full investigation at the time. Even if the Keilor Skull had proved to be a burial, the charcoal, calcined bones, red ochre and implement found together in the terrace (apparently associated with the diastem) provide sufficient evidence of human occupation at the time the Keilor Terrace was being deposited. The skull was a few feet from the lenticle of charcoal, etc.

Tertiary Marsupials. A fragmentary ramus of the mandible of a marsupial was found some years ago in a Lower Pliocene marine shell bed near Hamilton, Victoria. The fluorine test, foraminifera and matrix obtained from a tooth cavity and around the base of a tooth, and the circumstances of collection all combine to establish the validity of this important fossil. A well-preserved third molar tooth is hypsodont and sharply bilophodont, showing the typical specialization for the grassland habitat. It is a *Macropus* in the wide sense, and proves that the Macropodidæ did not evolve in the late Tertiary (cf. ref. 4, p. 12).

In a fossil podsol soil with Tertiary plants in position of growth, overlying the marine beds from which came the *Macropus*, and sealed off by a basalt flow, I have found an upper molar of a cuscus. The soil is almost certainly of Upper Pliocene age[5]. A subtropical rain-forest environment is suggested by both the cuscus and the associated flora.

The known Australian Tertiary marsupials are now therefore three in number, namely:

Period	Fossil	Habitat
Upper Pliocene Lower Pliocene	Cuscus *Macropus* (kangaroo)	Rain-forest Grassland or open forest
Lower Miocene to Upper Eocene (authors vary on age)	*Wynyardia bassiana* (possum)	Forest

The first two come from Victoria and the third from Tasmania. Two are phylangerids and one a macropodid. All are diprotodonts and herbivores. All are of sizes comparable with their extant congeners, and the evidence (so far as it goes) suggests that the marsupials were small in the Tertiary, giant in the Pleistocene, and small again in the Holocene. The small forms co-existed with the giant ones in the Pleistocene, but in much smaller numbers, judging by the number of fossils found. The process of switching back to smaller forms appears to be still going on, for the bigger kangaroos are tending to die out, whereas the small marsupials are thriving. Five sites indicate that the Australian aborigines were here in the time of the giant marsupials, so since then the aborigines have had to adjust themselves to climatic changes, to the attendant vegetational and physiographical changes, and to changes in their food fauna and flora.

Full details of the above and associated investigations are being published in the *Memoirs* of this Museum.

Edmund D. Gill

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Australia.
March 12.

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[2] Keble, R. A., and Macpherson, J. H., *Mem. Nat. Mus. Melb.*, **14**, (2), 52 (1946).
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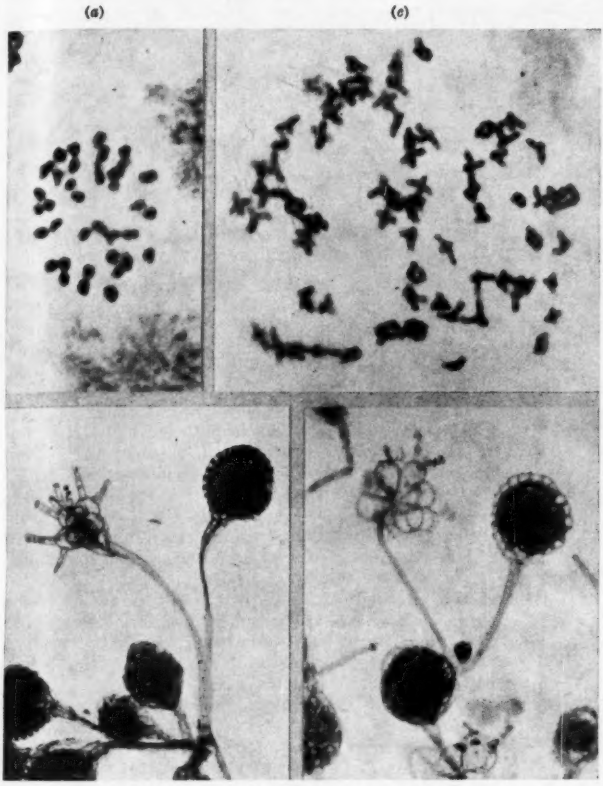
Two Cytological Forms of *Polypodium virginianum* in Eastern North America

P. virginianum L. is the only representative of the *P. vulgare* complex which is known to occur on the eastern seaboard of North America. It has hitherto been regarded as a well-characterized species readily distinguishable from all others by the possession of a striking type of stellate paraphysis which has been intensively studied by Martens[1] and his collaborator, who regard them as modified sporangia. The chromosome number has previously been reported by one of us to be diploid[2].

Fig. *a* shows a metaphase plate obtained in 1953 from the diploid plant from Halifax, Nova Scotia, previously described and figured. The chromosome number, as stated, is 37, and one of the characteristic paraphyses is illustrated in Fig. *b*. We have a similar diploid plant, obtained afterwards from near Ottawa, which was referred to in a later publication[3] as coming from the province of Ontario. This attribution is not quite correct, since we have now learnt that the original site of collection was "on the Gatineau river, 10 miles north of Ottawa", and therefore actually over the border into the province of Quebec. It is, however, also diploid, as stated, and it serves to show that this form of the species is probably the prevailing one, at least in the regions immediately adjacent to the St. Lawrence estuary.

A third plant of the species posted to us in 1948 but only recently examined is, however, not diploid. It is a tetraploid without quadrivalents (Fig. *c*), but it nevertheless bears stellate paraphyses of the same general type as the preceding (Fig. *d*). They are less numerous, being only about four per sorus instead of about twenty per sorus, and the cell size is

larger. There may be other morphological differences, but the range of form in paraphyses of the same plant is so varied that precise comparisons are not easy. The plant came from "10 miles north of Kingston, Ontario".



(*a*) First meiotic metaphase of *P. virginianum* from Nova Scotia with $n = 37$. (× 1,000.) (*b*) Sporangia and a paraphysis of the same. (× 50.) (*c*) Diakinesis in the tetraploid to show absence of quadrivalents. (× 1,000). (*d*) Sporangia and paraphyses of the tetraploid. (× 50)

On the basis of only a single specimen of the tetraploid, we cannot usefully attempt a full morphological comparison of the two forms, though it is to be hoped that with more ample material it will be possible to detect some simple diagnostic differences for distinguishing them in the field. We therefore wish to direct the attention of local American or Canadian botanists to this problem, and we would welcome further information or material which might elucidate the relative geographical distributions of the two forms.

Their genetical affinity is in the meantime being investigated in Leeds.

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Factors affecting the Regeneration of Root-Cuttings

Root-cuttings can be used for the rapid vegetative propagation of many plants; but, despite certain advantages, the method has not been widely employed in British horticultural practice, possibly because of its apparent uncertainty. Batches of cuttings which appear to be quite suitable may sometimes give a high proportion of successes and at other times fail completely. Recent work on the regeneration of root cuttings may throw an interesting light on this question.

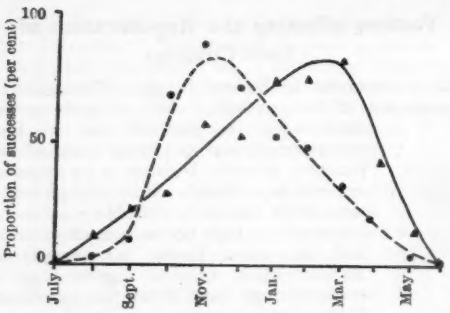
Most of the initial work was done with raspberries (*Rubus idæus* L.) of the varieties Lloyd George and Malling Promise. Roots were dug at intervals during a period of four years from plants up to two years old and made into cuttings, which were mainly 8–12 cm. long and 2–4 mm. in diameter. The cuttings were inserted horizontally in three different environments: namely, heated glasshouse (58 batches, comprising a total of 1,507 root-cuttings planted 2–3 cm. deep); unheated frames (24 batches, 648 cuttings, 2–3 cm. deep); and open ground in full sun (46 batches, 1,093 cuttings, 3–5 cm. deep).

Although all the roots used were healthy, usually well-furnished with buds and apparently ideal propagating material, the proportion of root-cuttings which regenerated varied widely between different seasons of the year. Most of those taken from May to July died, but from August to April a higher proportion regenerated, and by far the greatest percentage of successes were from cuttings taken in the winter months.

Such a marked seasonal effect was not unexpected. The work of propagators such as Stewart[1] at the Royal Botanic Garden, Edinburgh, has shown that stem cuttings of many species regenerate more readily at one season than another, and it was therefore not surprising to find that roots also showed a rhythmic seasonal response to propagation by cuttings.

However, further analysis shows not only well-marked 'on' and 'off' seasons for the propagation of raspberry root-cuttings but also distinct trends in their responses to different environments at different seasons. These trends are indicated in the diagram, which shows the results of a typical year's work with the variety Malling Promise. Results in other years and in experiments with the variety Lloyd George have shown similar trends.

During the 'on' season, from autumn to spring, the proportion of successes in the glasshouse tends to rise to a peak for cuttings inserted during the months of January, February and March. On the other hand, out-of-doors the peak is reached much earlier, the best results being given by cuttings taken soon after the beginning of the 'on' season, with a decreasing proportion of successes from cuttings put in thereafter. Cold frames provide a micro-climate intermediate between a heated glasshouse and the open



Months of the year (July 1951–June 1952)
●—●—, Cuttings inserted out of doors; ▲—▲—, cuttings inserted in heated greenhouse

ground, and cuttings in this environment behaved in an intermediate way.

Thus success or failure in the propagation of raspberry root-cuttings appears to depend primarily on an annual rhythm which may be strongly influenced by environment. Cuttings taken during October or November are most likely to grow if given natural winter temperatures by planting out-of-doors, whereas those taken from December to February respond better if put in a cold frame, and from March to the end of the 'on' season the highest proportion of successes comes from cuttings put in a heated glasshouse. Thus it appears that, the later cuttings are taken in the 'on' period, the warmer must be the environment to promote growth and regeneration.

The experiments have been extended to include the propagation of a wide range of herbaceous and shrubby plants by root-cuttings grown under various environmental conditions, and it is hoped that the work may clarify the position, enabling a higher proportion of successes to be obtained, with certainty, by the use of root-cuttings. It is too early yet to suggest any generalizations, but there are indications of well-marked 'on' and 'off' seasons for the propagation of other species by root-cuttings and that the optimum temperature conditions for propagation may vary from one period to another within the 'on' season, as in the case of raspberries. The best season for propagation may thus depend on the nature of the environment into which the root-cuttings are to be put to grow.

The choice and preparation of raspberry root material, methods of making and planting the root-cuttings, and the subsequent management of the plants produced will be described in detail elsewhere.

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[1] Graham, R. J. D., *Sci. Hort.*, **4**, 97 (1936).

Diacetyl as a Flower Scent

A recent publication by Derx[1] recorded diacetyl as the cause of the butter-like scent of the flowers of *Fagræa racemosa* Jack. (Loganiaceæ); another case of the same phenomenon can now be recorded. This new observation was also made in the Botanic Garden at Bogor, Java. A flowering specimen of *Polyalthia canangioides* Boerl. var. *angustifolia* (Anonaceæ), a beautiful tree, exhaled a heavy odour of fresh butter. Some flowers were tested, with positive results, for the presence of diacetyl by the method described by Derx. The red, dichroitic, crystal needles of dimethylglyoxime–nickel appeared within 30 min., so it was concluded that in this case, too, the smell of the flowers is caused by diacetyl. Diacetyl has thus been found in flowers of plants belonging to different families.

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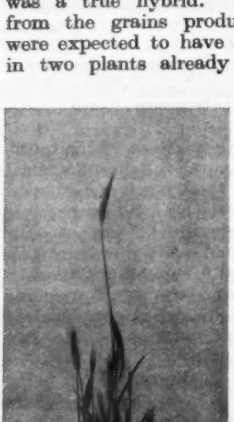
Behaviour of a *Triticum* × *Secale* Hybrid under the Action of Colchicine

In the spring of 1952 an attempt was made to double the chromosome number of a single wheat × rye F_1 hybrid plant with the object of obtaining a fertile amphidiploid. In view of the limited material available a method of injecting the culms with 0·05 per cent colchicine was adopted.

One culm, a little more advanced than the rest, was not treated since it was believed that the stage of meiosis had already been reached. It grew normally and gave a sterile spike typical of F_1 *Triticales*. The treated culms were injected 5–7 times, but this was found to be excessive. Growth stopped, the last node and subjacent region showed *c*-tumors, and the upper tissues were destroyed and no spikes developed. Adjacent, untreated culms showed reduction in growth and gave normally fertile spikes (see photograph). Presumably colchicine had passed from the treated culms to the untreated ones and acted on meiosis or on cells just before meiosis.

The original plant was produced by crossing 'Ardito' wheat ($2n = 42$) with 'Petkus' rye ($2n = 14$), and the appearance of the sterile spikes showed that it was a true hybrid. On this basis, the plants from the grains produced by the fertile spikes were expected to have 56 chromosomes. However, in two plants already counted, 42 chromosomes were found, and one of these plants which developed to maturity is identical with 'Ardito' wheat.



In order to explain these results, one would have to consider the remote possibility of the original 'plant' developing from two embryos, one of which would be a true hybrid and the other the result of a self-pollinated ovule. More probably, however, it appears that rye chromosomes were lost during the divisions under the action of colchicine. As confirmation of this is the fact that knobs, which are characteristic of rye chromosomes, were not observed.

Assuming that this explanation is correct, we are led to conclude that the derived wheat plant is completely homozygous since it has resulted from the duplication of a gametic set of chromosomes.

More extensive experiments are now being undertaken.

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Photosensitized Oxidation of Alcohols

RECENT investigations of the photo-oxidation of alcohols, sensitized by benzophenone[1] and by azo-dyes[2], while providing valuable information regarding the general form of the reaction, do not enable its detailed mechanism to be specified. Using anthraquinonoid sensitizers, however, it has been possible to obtain diagnostic evidence as to the nature of the individual processes concerned.

Aqueous neutral or acid solutions of the alcohol containing small quantities (10^{-3}–10^{-4} M) of anthraquinone 2 : 6 disodium sulphonate were irradiated (λ *c.* 3650 A.) in presence of oxygen at a shaking speed of 600 cycles/min.

The chief features of the photosensitized oxidation of ethanol are :

(1) The rate of oxygen uptake at constant pressure is virtually independent of the reactant concentrations but is proportional to the first power of the rate of light absorption. Also the quantum yield is approximately unity and is independent of temperature (0–40° C.). Hence a non-chain mechanism is in operation.

(2) The reaction products consist simply of acetaldehyde, acetic acid and peroxide (almost entirely hydrogen peroxide). It has been demonstrated conclusively that, except at low alcohol concentrations, acetic acid arises directly from the ethanol ; it is not the result of secondary oxidation of the acetaldehyde.

(3) Product yields based on the oxygen absorbed by the system are independent of light intensity and alcohol concentration, but vary significantly with oxygen pressure and sensitizer concentration. The limiting conditions are :

Oxygen pressure Sensitizer concentration	Low High	High Low
Acid yield	0 per cent	55 per cent
Aldehyde yield	100 ,,	18 ,,
Peroxide yield	100 ,,	70 ,,

(4) The reaction-rate and product yields are independent of *p*H under non-alkaline conditions. This, together with other evidence, suggests that the photo-oxidation occurs by a free-radical mechanism.

(5) The anthraquinonoid sensitizer operates by a cyclic mechanism ; its concentration remains unchanged after the absorption of many times the equivalent amount of oxygen. At low oxygen pressures, measurable quantities of the corresponding anthrahydroquinone are produced, indicating that the initial attack by the photo-excited sensitizer molecule involves abstraction of hydrogen from its surroundings. Since this does not occur in absence of the substrate, it follows that the hydrogen is removed from the alcohol, with the simultaneous production of a semi-quinone radical. At high oxygen pressure, this is rapidly re-oxidized to the anthraquinone form ; at low oxygen pressure, further reduction to the anthrahydroquinone can occur.

These observations may all be interpreted in terms of the following reaction scheme :

(1)	A	$+ h\nu$	$\rightarrow A^*$
(2)	A^*	$+ R\mathrm{H}$	$\rightarrow A\mathrm{H}— + R—$
(3)	$R—$	$+ \mathrm{O_2}$	$\rightarrow R\mathrm{O_2}—$
(4)	$A\mathrm{H}—$	$+ \mathrm{O_2}$	$\rightarrow A + \mathrm{HO_2}—$
(5)	$R—$	$+ A$	$\rightarrow A\mathrm{H}— +$ aldehyde
(6)	$R\mathrm{O_2}—$	$+ R\mathrm{O_2}—$	$\rightarrow$ 2 acid $+ \mathrm{H_2O_2}$
(7)	$R\mathrm{O_2}—$	$+ \mathrm{HO_2}—$	$\rightarrow$ aldehyde $+ \mathrm{H_2O_2} + \mathrm{O_2}$
(8)	$\mathrm{HO_2}—$	$+ \mathrm{HO_2}—$	$\rightarrow \mathrm{H_2O_2} + \mathrm{O_2}$
(9)	$R—$	$+ R—$	$\rightarrow$ aldehyde $+ R\mathrm{H}$
(10)	$R—$	$+ R\mathrm{O_2}—$	$\rightarrow$ 2 aldehyde $+ \mathrm{H_2O_2}$
(11)	$R—$	$+ \mathrm{HO_2}—$	$\rightarrow$ aldehyde $+ \mathrm{H_2O_2}$
(12)	$A\mathrm{H}—$	$+ A\mathrm{H}—$	$\rightarrow A\mathrm{H_2} + A$

$R\mathrm{H}$ represents the alcohol, $R—$ the radical $R.\mathrm{C}(\mathrm{H})(\mathrm{OH})—$, while $R\mathrm{O_2}—$ corresponds to $R.\mathrm{C}(\mathrm{H})(\mathrm{OH})—\mathrm{OO}—$ and $A\mathrm{H}—$ to the semi-quinone radical. When acid production is favoured, reactions (1)–(4) and (6)–(8) predominate.

Applying stationary-state conditions to this scheme it can be shown that :

(*a*) To a first approximation over the whole range of oxygen pressure and sensitizer concentration :

$$\frac{1}{(\text{acid yield})^{1/2}} = C' + C''\frac{[A]}{[\mathrm{O_2}]},$$

where C' and C'' are constants.

(*b*) At high $[\mathrm{O_2}]$ and low $[A]$:
Acid yield $\times$ 3/2 + aldehyde yield = 100 per cent.
Acid yield + aldehyde yield = peroxide yield.

(*c*) At low $[\mathrm{O_2}]$ and high $[A]$: aldehyde yield = peroxide yield = 100 per cent.

The experimental data are in accordance with these relationships.

In many respects the above mechanism resembles those established for the autoxidation of unsaturated hydrocarbons[3] and aldehydes[4]. The completely different kinetic behaviour results from the fact that the peroxy-radicals are incapable of abstracting hydrogen from further alcohol molecules. Moreover, the products are derived almost entirely from the inter-radical terminating processes, which make only a minor contribution when reaction chains are being propagated. Hydroxy-hydroperoxide and hydroxy-peroxides do not figure significantly, among the products because they readily break down to aldehyde and hydrogen peroxide.

Photo-oxidations conducted in absence of water using anthraquinone as sensitizer, and also in aqueous solution using hydrogen peroxide, agree with the above picture. Similar considerations have been applied to secondary alcohols and α-glycols. *iso*-Propanol, for example, gives the expected 100 per cent yields of acetone and hydrogen peroxide at all oxygen pressures and sensitizer concentrations ; 2 : 3 butylene glycol, however, exhibits the additional feature of carbon-carbon bond fission.

This mechanism is of interest in connexion with the phototendering of cellulosic textiles, induced by certain anthraquinonoid vat dyes : it suggests how hydrogen peroxide[5] can arise and carbonyl groups can be introduced into the cellulose molecule. The latter, under the mild alkaline conditions of washing,

are then sufficient to bring about degradative reactions of the type recognized by Davidson[7] and recently interpreted by Corbett, Kenner and Richards[8]. It is important to emphasize, however, that this represents only one aspect of the complex tendering process.

This work forms part of the programme of fundamental research being carried out by the British Rayon Research Association.

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April 10.

[1] Bäckström, "The Svedberg Memorial Volume", 45 (1944).
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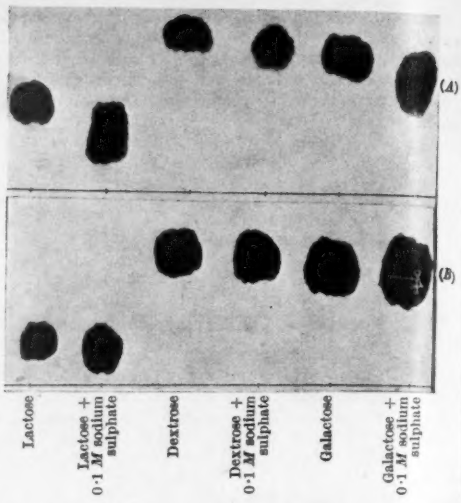

Duplicate chromatograms of sugars with and without 0·1 *M* sodium sulphate run in (*A*) *n*-butanol/ethanol/water/ammonia, and (*B*) *n*-propanol/ethyl acetate/water

Salt Interference in Sugar Chromatography of Urine

During a recent investigation of lactosuria in burns[1] following cutaneous absorption of the lactose from penicillin-lactose powder, it was found that ascending chromatography of the urine yielded spots of considerably lower R_F values than lactose itself. 0·02 ml. amounts of urine were applied; and the solvent consisted of *n*-butanol 5·7 parts, ethanol 1·57 parts, water 2·73 parts, and contained 1 per cent ammonia solution. The substance obtained from these spots, however, when isolated and identified by standard chemical procedures, proved to be lactose.

Similar anomalous R_F values could be obtained using the organic phase of a solvent system consisting of *n*-butanol 4 parts, water 5 parts and glacial acetic acid 1 part. The spots when sprayed with aniline hydrogen phthalate or *p*-anisidine hydrochloride showed a lower, more intensely staining region. When 0·1 *M* sodium sulphate or sodium phosphate was substituted for urine, similar results were obtained. Sodium chloride (0·2 *M*) or 2 per cent urea used as lactose solvents did not give lowered R_F values.

R_F values almost corresponding to those of the reference substance in water were given in a neutral solvent system containing *n*-propanol 7 parts, ethyl acetate 1 part, and water 2 parts. We therefore inferred that the phenomenon observed could not be entirely explained by hydration.

To investigate the possibility of compound formation, as suggested by the more intensely stained region, 2 per cent lactose in 0·1 *M* sodium sulphate was run two-dimensionally using a neutral solvent for the second development. Only one spot of similar R_F to the reference spot was obtained. Serial elution after loading a cellulose column prepared from Whatman No. 4 paper with lactose in sodium sulphate showed lactose contaminated with salt and pure lactose. The salt-contaminated fractions, when freed from the salt, showed identity with pure lactose. It was therefore concluded that no compound or complex was formed with the salt.

It is well known that organic acids will migrate in organic solvents either as the free acids or as their ammonium salts[2]. Definite though low R_F values are also given by inorganic acids and their salts. Duplicate chromatograms of lactose in sodium sulphate were run in *n*-butanol, ethanol and water containing ammonia. One was sprayed with bromophenol blue in 0·2 per cent aqueous citric acid. It was found that the darker-stained area shown when sprayed with aniline hydrogen phthalate corresponded to the upper region of the acid spot, which had migrated as its ammonium salt. The failure of sodium chloride to cause the interference is explained by its failure to migrate in the solvent system employed.

We also investigated whether the anomalous R_F values were produced by an initial delay only or by a persistent slowing throughout the run. Sugars of varying R_F values were chosen and the chromatograms run for 4, 6, 12 and 24 hours under identical conditions. The values show that the retardation is less marked the faster the sugar moves, but its relative magnitude is unaffected by time. This suggests that there is a persistent interference between the salt and the sugar causing a continuing elongation and fusion of the two spots in the case of slower-moving sugars.

Distance Travelled (mm. from Origin) by Sugars With and Without Sodium Sulphate (*n*-butanol/ethanol/water/ammonia)

Time (hr.)	Lactose	Lactose in 0·1 *M* sod. sulph.	Maltose	Maltose in 0·1 *M* sod. sulph.	Galactose	Galactose in 0·1 *M* sod. sulph.	Dextrose	Dextrose in 0·1 *M* sod. sulph.
4	17	10	18	12	27	20	31	27
6	19	12	26	16	33	28	40	32
12	33	22	38	26	58	47	61	56
24	42	28	47	31	70	58	80	72

In view of this experience, it is suggested that sugar chromatograms of biological material which it might be impractical to de-salt should be run in a neutral medium. We have found the *n*-propanol/ethyl acetate/water mixture described above highly suitable for separation of reducing sugars occurring in biological fluids.

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May 9.

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Slow-Neutron Scattering Cross-Sections of Magnesium

The bound-atom and the coherent scattering cross-sections of magnesium have been given[1] as 4·2 and 2·4 barns respectively, and it has been pointed out[2,3] that these values are inconsistent with later measurements. In order to decrease the margin of uncertainty, we have re-determined the free-atom scattering cross-section.

The total cross-section of magnesium has been measured using the arrangement shown in Fig. 1, which selects neutrons in the energy-range 0·5–1,000 eV. The number of neutrons scattered by the 2 gm./cm.^{2} of B_2O_3 or 0·070 in. of polythene is the same. Thus, if we denote the counting-rates with and without the sample when the polythene (boron) is in position by P_s (B_s) and P (B) respectively, the ratio $(P_s - B_s)/(P - B)$ will be the transmission of the sample for those neutrons which are absorbed by the 2 gm./cm.^{2} of B_2O_3. The calculated spectrum of these neutrons is shown in Fig. 2, and their calculated mean wave-length is 0·145 A. (3·9 eV.). Over the neutron energy-range covered by this spectrum, the absorption cross-section of magnesium is negligible[4] and the total cross-section is constant[4], so that our measurement is of the free-atom scattering cross-section.

Measurements were carried out with samples of magnesium metal and its oxide. The oxygen total cross-section[4] was subtracted from the magnesium oxide cross-section. The results obtained were 3·53 ± 0·14 and 3·49 ± 0·12 barns from the magnesium and magnesium oxide measurements respectively. The mean value is 3·51 ± 0·09 barns. This yields a calculated bound-atom scattering cross-section of 3·82 ± 0·10 barns compared to 3·8 ± 0·2 quoted in ref. 4.

The coherent scattering cross-section has been determined recently by the neutron diffraction[5] and the mirror[6] techniques, values of 3·4 ± 0·14 and 3·7 ± 0·15, respectively, being obtained. If the mean of these values is subtracted from our value for the bound-atom cross-section, a value of 0·27 ± 0·14

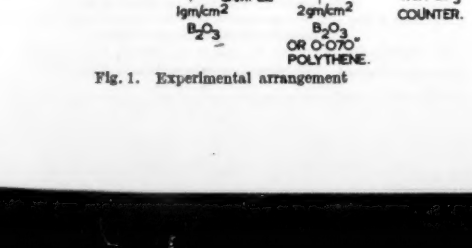

Fig. 1. Experimental arrangement

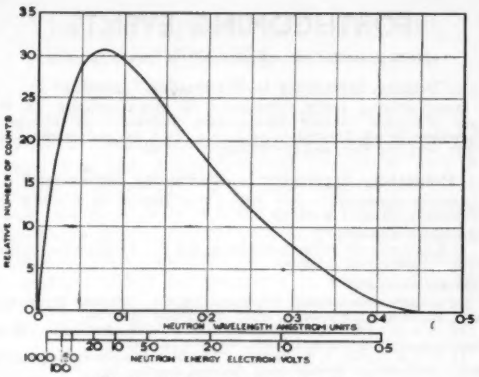

Fig. 2. Neutron wave-length spectrum

barn is obtained for the incoherent cross-section. This result is consistent with the direct measurements of Squires[3] (0·11 barn) and Egelstaff[6] (0·09 ± 0·02 barn) of the incoherent cross-section. Thus the values of the scattering cross-sections of magnesium are now in better agreement.

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June 8.

[1] Shull, C. G., and Wollan, E. O., *Phys. Rev.*, **81**, 527 (1951).
[2] Bacon, G. E., *Acta Cryst.*, **5**, 684 (1952).
[3] Squires, G. L., *Proc. Roy. Soc.*, A, **212**, 192 (1952).
[4] U.S.A.E.C.U. 2040 (1952).
[5] Heindl, C., and Ruderman, I. W., Columbia Univ. (N.Y.) Dept. Physics, Quarterly Report *CU* 97.
[6] Egelstaff, P. A., A.E.R.E., *N/R* 1165 (1953).

Photo-elastic Effect in Lead Nitrate

In an earlier communication[1], it was reported that barium nitrate behaves in an exceptional manner in respect of its photo-elasticity. Since then, crystals of lead nitrate have also been studied, and differences between the stress-optical constants, as determined by a Babinet compensator for the sodium D lines, are found to be:

$$(q_{11} - q_{12}) = -19{\cdot}13 \times 10^{-13}, (q_{11} - q_{12}) = -11{\cdot}84 \times 10^{-13} \text{ and } q_{44} = -1{\cdot}393 \times 10^{-13} \text{ c.g.s. units.}$$

These values are similar to those obtained in barium nitrate in being quite large. $(q_{11}-q_{12})$ is different from $(q_{11}-q_{12})$, as we should expect for the T_h class of crystals to which lead nitrate belongs. The difference is 60 per cent of the lower value and is very large indeed. As in barium nitrate, in this substance also, the birefringence produced by pressure along a cube axis is nearly fourteen times that produced by an equal pressure along a cube diagonal. The photo-elastic behaviour of lead nitrate is therefore to be regarded as highly anisotropic and very exceptional.

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April 10.

[1] *Nature*, **162**, 740 (1948).

FORTHCOMING EVENTS

*(Meetings marked with an asterisk * are open to the public)*

Tuesday, September 1—Wednesday, September 2

International Joint Commission on Oceanography (in the Jane Herdman Geology Laboratories, University of Liverpool, Brownlow Street, Liverpool), at 10 a.m. each day.—Symposium on "The Deep Sea Floor and the History of the Earth".

Wednesday, September 2—Wednesday, September 9

British Association for the Advancement of Science (at Liverpool).—Annual Meeting.

Wednesday, September 2

At 8.30 p.m.—Sir Edward Appleton, F.R.S.: "Science for its Own Sake" (Presidential Address).

Thursday, September 3

At 10 a.m.—Sir Edward Appleton, F.R.S.: "Finding Things (ut with Radio and Rockets" (Junior Presidential Address).

At 10 a.m.—Prof. G. R. Clemo, F.R.S.: "A Suggestion and Some Consequences" (Presidential Address, Section B).

At 10 a.m.—Prof. J. E. Smith: "The Maintenance and Spread of Sea-shore Faunas" (Presidential Address, Section D).

At 10 a.m.—The Rt. Hon. Lord Dudley Gordon: "Engineering in the Next Two Thousand Years" (Presidential Address, Section G).

At 10 a.m.—Prof. J. Walton: "The Evolution of the Ovule in the Pteridosperms" (Presidential Address, Section K).

At 12 noon.—Prof. D. W. Harding: "Psychological Problems in the Recognition of Excellence" (Presidential Address, Section J).

At 2.30 p.m.—Dr. W. E. Swinton: "Gateways of Science" (Presidential Address, Section X).

Friday, September 4

At 10 a.m.—Prof. Sir Harold Jeffreys, F.R.S.: "Half a Century of Geophysics" (Presidential Address, Section A).

At 10 a.m.—Prof. R. H. Kinvig: "The Geographer as Humanist" (Presidential Address, Section E).

At 10 a.m.—Prof. F. W. Paish: "Open and Repressed Monetary Inflation" (Presidential Address, Section F).

At 10 a.m.—Prof. M. Fortes: "Analysis and Description in Social Anthropology" (Presidential Address, Section H).

At 10 a.m.—Mr. Robert Birley: "Greek or Chemistry or Both"? (Presidential Address, Section L).

At 10 a.m.—Dr. J. Hammond, F.R.S.: "Applications of Animal Physiology to Agriculture" (Presidential Address, Section M).

At 8 p.m.—Sir Ben Lockspeiser, F.R.S.: "Fifty Years of Powered Flight".

Monday, September 7

At 10 a.m.—Prof. T. Neville George: "Invertebrate Fossils and Evolution" (Presidential Address, Section C).

At 10 a.m.—Dr. D. P. Cuthbertson: "Quality and Quantity of Protein for Man and Livestock" (Presidential Address, Section I).

At 8 p.m.—Mr. Eric Shipton: "Mount Everest".

Wednesday, September 2—Saturday, September 12

National Radio and Television Exhibition (at Earls Court, London, S.W.5).*

Thursday, September 3—Thursday, September 17

Chemical Plant Exhibition (at Olympia, London, W.14).*

APPOINTMENTS VACANT

Applications are invited for the following appointments on or before the dates mentioned:

Chemist (with good honours degree or equivalent professional qualification, and preferably two or three years general experience in industrial laboratories) at the Central Laboratory, Chiswick—The Staff Officer (F/EV247), London Transport, 55 Broadway, London, S.W.1 (September 5).

Civil Engineer (preferably Corporate Member of the Institution of Civil Engineers) in the Generation Construction Department—The Director of Establishments, British Electricity Authority, Winsley Street, London, W.1, quoting AE/406 (September 5).

Senior Scientific Officer (with good honours degree in botany or agricultural botany and research experience in genetics and/or plant breeding) and a Scientific Officer (with good honours degree in botany or agricultural botany) in the Grass Breeding Section—The Registrar, Welsh Plant Breeding Station, University College of Wales, Aberystwyth (September 5).

Assistant, male (with sound training in laboratory methods, both physical and chemical, and preferably with experience in biological work), for work on the development of storage techniques for fruit—The Secretary, East Malling Research Station, Maidstone, Kent (September 7).

Physiologist (preferably with neurophysiological experience) in the Department of Applied Electro-Physiology for duties which will include the supervision and interpretation of EEGs, EMGs, and other electro-clinical investigations, and research in these and related subjects, on human and animal material—The Secretary, The National Hospital, Queen Square, London, W.C.1 (September 7).

Assistant Experimental Officer or Experimental Officer at the Agricultural Research Council Plant Virus Research Unit, Cambridge, to work on insect virus diseases—The Secretary, Agricultural Research Council, Cunard Building, 15 Regent Street, London, S.W.1 (September 8).

Demonstrator in Electrical Engineering and Physics (with degree or equivalent qualification, and preferably with industrial experience) to assist in organization, preparation and control of work in electrical and physics laboratories—The Principal, Royal Aircraft Establishment Technical College, Farnborough (September 8).

Research Assistant (with good honours degree in chemistry) in the Department of Chemistry—The Professor of Chemistry, Royal Holloway College, Englefield Green, Surrey (September 14).

Assistant Lecturer (with special interests in research into child psychology) in the Department of Psychology, and a Research Assistant to carry out experimental work under the Professor of Psychology—The Registrar, The University, Manchester 13 (September 15).

Assistant Lecturer (Grade III) or Lecturer (Grade II) in Inorganic Chemistry—The Registrar, The University, Bristol (September 16).

Chemists (with good honours degree or equivalent) in the Coal Survey Laboratories at Cardiff and Chester, to undertake analytical and investigational work—The National Coal Board, Establishments (Personnel), Hobart House, Grosvenor Place, London, S.W.1, quoting TT/677 (September 19).

Lecturer or Assistant Lecturer in Chemistry (with special interest in inorganic or analytical chemistry)—The Registrar, The University, Sheffield (September 19).

Research Officer (with university honours in agricultural science, or a degree with postgraduate research experience; or an honours degree in science, with agricultural training and experience) in the Commonwealth Scientific and Industrial Research Organization, Land Research and Regional Survey Section, Canberra, to participate in investigations concerning land use potentialities of undeveloped regions of the Commonwealth and to assist in preliminary surveys for special purposes—The Chief Scientific Liaison Officer, Australian Scientific Liaison Office, Africa House, Kingsway, London, W.C.2, quoting 570/26 (September 19).

Senior Research Officer or Research Officer (with honours degree in agriculture or science, and experience in research in plant nutrition) to carry out investigations into plant nutrition and biological problems, with particular reference to the cultivation of fruit trees, including citrus (Ref. No. 500/65); Senior Research Officer or Research Officer (chemist) (with honours degree in science or agricultural science or equivalent qualifications, and preferably with research experience in soil chemistry) to conduct research into various chemical aspects of plant growth and soil problems (Ref. No. 500/66), at the Commonwealth Scientific and Industrial Research Organization Irrigation Research Station, Griffith, New South Wales, Australia—The Chief Scientific Liaison Officer, Australian Scientific Liaison Office, Africa House, Kingsway, London, W.C.2, quoting appropriate Ref. No. (September 19).

Director (with high qualifications in agriculture or in one of the agricultural sciences, and with proved administrative ability, preferably with experience of tropical agriculture) of an Agricultural Research and Training Institute in Burma; which is to be established for the improvement of Burmese agriculture by applied research and education—The Burmese Embassy, 19A Charles Street, London, W.1 (September 22).

Director (with high qualifications in veterinary science and proved administrative ability and preferably with experience in tropical veterinary medicine) of a Veterinary Research and Training Institute in Burma, which is to be established for the improvement of Burmese livestock by applied research and education—The Burmese Embassy, 19A Charles Street, London, W.1 (September 22).

Lecturer (preferably with a medical qualification and some experience in protozoology) in the Department of Parasitology to carry out teaching and research work under the direction of the Head of the Department—The Dean, London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1 (October 1).

Lecturer in Clinical Chemistry—The Secretary, The University, Aberdeen (October 15).

Chemist (with good honours degree in chemistry and an ability to study agronomic problems and with knowledge of soil chemistry and physics) at the Sugarcane Research Station, Mauritius—The Director of Recruitment, Colonial Office, Great Smith Street, London, S.W.1, quoting 27106/37.

Lecturer or Assistant Lecturer in the Department of Electronics—The Secretary and Registrar, The University, Southampton.

Physicist (with first- or second-class honours degree in science, and preferably five years experience as a hospital physicist) in the Medical Department of Hong Kong—The Director of Recruitment, (Colonial Service), Colonial Office, Sanctuary Buildings, Great Smith Street, London, S.W.1, quoting CDE.117/51/013.

Physicists, Mathematicians and Engineers (Scientific Officer, Experimental Officer and Assistant Experimental Officer grades) at the National Aeronautical Establishment, Bedford—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting A.209/53A.

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